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REPORTS OF THE
PRINCETON UNIVERSITY EXPEDITIONS
TO PATAGONIA, 1896-1899

J. B. HATCHER

IN CHARGE

EDITED BY

WILLIAM B. SCOTT

BLAIR PROFESSOR OF GEOLOGY AND PALÆONTOLOGY, PRINCETON UNIVERSITY

VOLUME VII

PALÆONTOLOGY IV



PRINCETON, N. J.

THE UNIVERSITY

STUTT GART

SCHWEIZERBART'SCHE VERLAGSHANDLUNG (E. NÄGELE)

1910-1932

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PRINCETON UNIVERSITY EXPEDITIONS TO PATAGONIA
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VOLUME VII
PALÆONTOLOGY IV

PART I LITOPTERNA OF THE SANTA CRUZ BEDS

By
WILLIAM B. SCOTT
PRINCETON UNIVERSITY

PART II AVES OF THE SANTA CRUZ BEDS

By
WILLIAM J. SINCLAIR AND MARCUS S. FARR
PRINCETON UNIVERSITY

PART III NATURE AND ORIGIN OF THE SANTA CRUZ FAUNA
WITH ADDITIONAL NOTES ON THE ENTELONYCHIA AND ASTRAPOTHERIA

By
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By W. B. SCOTT.

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ERRATA.

Page 53, line 15: Strike out *Tichodon*.

Page 60, line 25: *For* (Pls. XI, fig. 4, etc.) *read* (Pls. XI, fig. 8, etc.).

Page 203, line 20: *For* (Plate G) *read* (Plate J).

Page 212, line 12: *For* (Pl. G) *read* (Pl. J).

 line 20: *For* Plate H, *read* Plate G.

Page 213, line 9: *For* (Plate J) *read* (Plate H).

Page 217: after line 9: *Insert* TOXODONTIDÆ (10).

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ERRATA.

Page 53, line 15 : Strike out *Tichodon* from the list of synonyms of *Proterotherium*.

Page 60, line 25 : *For* (Pls. XI, fig. 4, etc.) *read* (Pls. XI, fig. 8, etc.).

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MAMMALIA OF THE SANTA CRUZ BEDS.

PART I. LITOPTERNA.

BY

WILLIAM B. SCOTT,

PRINCETON UNIVERSITY.

THE memoir on the Litopterna was originally to have been written by the late Mr. Hatcher, but through his lamented death, the work has devolved upon myself. Unfortunately, during my visit to La Plata, my limited time was so fully taken up with other groups of Santa Cruz fossils, that it was impossible for me to make any satisfactory studies of the Litopterna in the collections of Dr. Ameghino and the La Plata Museum. This lack has, to some extent been repaired by the kindness of Dr. Ameghino, who has with his usual courtesy sent me excellent photographs and plaster-casts of nearly all of his types of the Santa Cruz Protherootheriidæ and these have proved very helpful in the determination of the genera and species.

The materials for the study of this group in the collections of Princeton University and the American Museum of Natural History are abundant and admirably preserved, and a very full account of the dental and skeletal structure may be given. On the other hand, the determination of species, more particularly of the genus *Protherootherium*, is exceeding difficult. To solve the problem of species in a satisfactory and convincing manner, it would first be necessary to have a detailed stratigraphical knowledge of the Santa Cruz formation and, further, to ascertain the exact position in the beds of every specimen collected. In the absence of such knowledge, it is not yet practicable to distinguish contemporary and fluctuating variations from successive and relatively fixed mutations, and where a genus was in a state of vigorous development, the number of species which should be assigned to it becomes largely a matter of conjecture. For the most part, the genera of the Santa Cruz Litopterna are well-defined and easily distinguishable, save such as are still very incompletely known, and the families are even better and more clearly distinguished.

It is still a matter of some uncertainty as to the number of families represented among the Santa Cruz Litopterna. At one time or another, Ameghino has referred to this order four families, the Notohippidæ, Proterotheriidæ, Macrauchenidæ (including the Mesorhinidæ) and the Adianthidæ. Of these, the Notohippidæ, which Ameghino has latterly referred to the horses, his order "Hippoidea" ('04, 33), I agree with Roth ('03, 33) in regarding as nearly allied, if not actually referable, to the Toxodontia. As to the Proterotheriidæ and Macrauchenidæ there is no difference of opinion, they are clearly defined and unmistakable family groups. The Adianthidæ are so very imperfectly known, that their status is still quite uncertain; they are here merged with the Macrauchenidæ, from which a separation of them is, at present, at least premature.

The Litopterna are an unusually interesting group of mammals, because of the fundamental problems of descent which they raise, and a definite determination of their systematic position and relationships will illuminate many obscure questions of evolutionary philosophy. Especially is this true as regards the great problem of parallel and convergent development, the independent acquisition of similar structures in unrelated or remotely related groups.

The *dentition*, which is always brachyodont in all of the known members of the order, differs considerably in the two Santa Cruz families, more particularly in the anterior region. In the Proterotheriidæ the constant dental formula is $I_{\frac{1}{2}}^{\frac{1}{2}}$, C_1^0 , $P_{\frac{1}{4}}^{\frac{1}{4}}$, $M_{\frac{3}{8}}^{\frac{3}{8}}$, and the single upper incisor and external lower incisor (i_1^2 and $i_{\frac{1}{3}}$) are enlarged, growing from persistent pulps, to four small, sharp-pointed tusks; the upper canine is lost and the lower is so small as to be nearly or quite functionless. In the Macrauchenidæ the number of teeth is unreduced from that typical of nearly all groups of early placental mammals, giving the formula $I_{\frac{3}{8}}^{\frac{3}{8}}$, C_1^1 , $P_{\frac{1}{4}}^{\frac{1}{4}}$, $M_{\frac{3}{8}}^{\frac{3}{8}}$. The incisors, canines and foremost premolars are of subequal size and simple, compressed conical form.

In all of the Litopterna, even those of the Pleistocene, the premolars are nearly all simpler in pattern than the molars. In the Santa Cruz genera the fourth (and sometimes the third) lower premolar is quite molari-form, and the fourth upper approximately so. The molars have a pattern which has often been compared to that of *Palæotherium*, but, so far as the upper teeth are concerned, the resemblance is not at all close and, indeed, the plan is quite different from that of any of the lophodont Perissodac-

tyla. The upper molars have two equal, concave and somewhat crescentic, external lobes, which unite in a mesostyle, and two principal internal, more or less conical cusps (the proto- and hypocone). Anterior and posterior conules are prominently developed, but do not fuse into well-defined transverse crests, the posterior crest being especially incomplete. The internal cingulum is so elevated as to enclose deep fossettes, the number and position of which differ in the various genera. The internal cusps are always close together and often connate, or connected by a ridge. The lower molars are composed of two crescents, one behind the other, a pattern which is common in early members of both Artiodactyla and Perissodactyla, such as the Anoplotheres, Palæotheres, Titanotheres, etc. A very characteristic feature is the pillar or spur in the inner concavity of the posterior crescent, which, there is reason to believe, was originally common to all of the Litopterna, but in the Santa Cruz several genera have it in very reduced form and others have lost it altogether. It is more reduced in the Proterotheriidæ and in *Adianthus*, more developed in the other Macrauchenidæ. The Pampean genus *Macrauchenia* has no trace of it in the true molars, but retains it in the milk-premolars. The third lower molar may have a small talon, but more commonly there is none.

All of the antemolars have predecessors in the milk-series, the teeth of which in general resemble their permanent successors. The deciduous grinding teeth, except dp 4, unlike those of the perissodactyls, are simpler than the permanent molars.

The *skull* differs much in the two families, being of more normal appearance in the Proterotheriidæ than in the Macrauchenidæ, in which the nasal bones are greatly shortened and the anterior nares correspondingly enlarged, showing that a proboscis was at least in an incipient stage of development. No alisphenoid canal is present in any known member of the group and the foramina rotundum and ovale are confluent. The tympanic is very loosely attached to the skull and imperfectly ossified not forming a bulla, but merely a small plate, with large, irregular meatus externus, which is not at all tubular. A high sagittal crest is present in all of the genera of both families.

One of the most noteworthy differences between the two families is in the length of the neck; in the Proterotheriidæ the neck is very short and the canal for the vertebral artery occupies the normal position, perforating the transverse processes of the cervical vertebræ. In the Macrauchenidæ,

on the other hand, the neck is greatly elongated and, in most of the cervicals, the vertebrarterial canal passes through the neural arch, very much as in the Tylopoda, to which *Macrauchenia* was originally referred. In both groups, the odontoid process of the axis retains its primitive cylindrical form. The number of trunk-vertebræ is not positively known for any genus of either family, but it is very probable that this number is 19 in the Macrauchenidæ and 21-22 in the Proterotheriidæ. The lumbar and posterior thoracic vertebræ have zygapophyses of the semicylindrical, interlocking type, which is especially characteristic of the Artiodactyla, but is found also in the horses. The last two lumbar and the first sacral have additional articulations by means of large facets on the transverse processes. The sacrum is long, tapering much posteriorly, which indicates that the tail was short, though no caudal vertebræ have yet been found.

The *limbs* are long and slender, but the feet are only moderately elongate, except in one monodactyl genus (*Thoatherium*) of the Proterotheriidæ. The scapula has both acromion and metacromion, which are most prominently developed in the Macrauchenidæ. No clavicle is known. The humerus is short and has a very simple, pulley-like trochlea. The fore-arm bones are separate in all of the Santa Cruz Litopterna and the ulna is remarkably large, while the radius is relatively slender. The femur has a prominent third trochanter and a large pit for the plantaris muscle. The leg-bones are not ankylosed in any of the Santa Cruz genera, but the fibula, though complete, is much more reduced than the ulna and always retains an articulation with the calcaneum.

The *feet* are quite different in the two families, though both are characterized by mesaxonic, or perissodactyl symmetry. In the Proterotheriidæ they have a very horse-like appearance, the median digit being much enlarged and supporting the whole weight, while the lateral digits are reduced to mere dew-claws. In one genus of this family, *Thoatherium*, complete monodactylism is attained and only minute vestiges of the lateral metapodials remain. The ungual phalanges have a decidedly equine character. On the other hand, in the Macrauchenidæ, the feet are functionally tridactyl and almost isodactyl, the three digits being of approximately equal length and thickness, though the median, or third, is slightly the longest. The ungual phalanges are short and heavy, almost nodular, and have a rhinocerotid rather than an equine appearance. In both families,

the arrangement of the bones in the carpus and tarsus is much more primitive than in even the most ancient and primitive known perissodactyls. In the carpus the arrangement is almost serial, except that the scaphoid extends over upon the magnum, though the lunar is widely separated from the unciform. The calcaneum bears a large facet for the fibula and the astragalus has a depressed-convex head, which rests only upon the navicular and has no contact with the cuboid. The tarsus is thus not at all perissodactyl in character, but is more like that of the Toxodonta, Typotheria and other South American ungulate groups. The mode of digital reduction is that which Kowalevsky has called "in-adaptive," and even in the monodactyl *Thoatherium*, the articulations of the carpals and tarsals with the metapodials show but little modification of the plan characteristic of a pentadactyl foot.

SYSTEMATIC POSITION OF THE LITOPTERNA.

That the Litopterna have a strong resemblance to the Perissodactyla, it needs no argument to prove, but is obvious at the first glance. The interpretation of this resemblance in terms of genetic relationship is a very different and by no means easy problem. It is not surprising that students of the Litopterna should have reached opposite conclusions regarding the systematic position of the group, for this is merely another case of the oft recurring problem, as to how far certain resemblances are offset by differences of structure. The answer to this question is largely conditioned by the opinion which is held concerning the mode in which the evolutionary process acts, and how generally similar structures are acquired in unrelated, or distantly related groups. Even though such parallelism of development be admitted to the fullest extent, great difficulties arise in the application of the principle to concrete cases and in distinguishing between those resemblances which are the evidences of genetic relationship and those which have been independently acquired. No better illustration of this general problem could be desired than that afforded by the Litopterna.

It would seem that the general opinion is that the Litopterna are nearly related to the Perissodactyla. Ameghino, who first distinguished and named the group, has all along maintained its perissodactyl relationship, and, in his later publications, has not employed the term Litopterna, but has simply referred the families to the Perissodactyla ('04, 52). This is the more remarkable, since he now separates the horses from the Perissodactyla as

a distinct order, the Hippoidea (*op. cit.*). Zittel also does not recognize the group as of even subordinal rank, but includes the families among the perissodactyls ('91, 263, 267), an example which is followed by Gaudry and apparently also by Roth ('03). Lydekker, on the other hand, holds a very different view and believes that the Litopterna, the Toxodontia and the Astrapotheria "have originated from a common ancestral stock, though apparently before the perissodactyles were differentiated from an earlier group known as the Condylarthra" ('96, 77). This represents very nearly the conclusion which I have reached, that *the Litopterna are more nearly related to the Toxodontia than to the Perissodactyla*, and that *the striking resemblances to the latter are largely due to parallelism of development, but in part also to the retention of certain primitive characters once common to all ungulates, or even to all mammals*.

The significant likenesses between the Litopterna and the Perissodactyla are, to a very great extent, conditioned by the fact that in both groups the feet are constructed upon a plan of mesaxonic symmetry, while such structures as are unaffected by this symmetry are, for the most part, fundamentally different in the two orders, and are much more primitive in all of the Litopterna than in the most ancient known perissodactyls. Indeed, one highly significant result of a comparison of the two groups is that their earlier representatives are no more alike than their later members. In other words, *so far as their history can be traced back, the two orders show no signs of converging to a common ancestry*.

The resemblances between the Litopterna and the Perissodactyla are not so much between the two groups, as wholes, as between the horses and the Proterotheriidæ, which are certainly very remarkable, and yet even here, the fundamental dissimilarity of plan is none the less obvious, as revealed in all parts of the skeleton, but especially in the carpus and tarsus. In addition to the mesaxonic symmetry of the feet and the lophodont molar plan, the only other point of special resemblance to the perissodactyls is the third trochanter of the femur. This, however, is a feature common to nearly, if not quite, all early mammalian groups, and therefore is of no great weight in deciding questions of relationship.

The more significant differences between the Litopterna and the Perissodactyla are expressed in the following table.

PERISSODACTYLA.

Upper molars with conules early fusing into two transverse crests.
Lower molars without pillar in posterior crescent.

Alisphenoid canal present.

Tympanic usually forming a bulla.

Odontoid process of axis spout-shaped in long-necked genera.

Zygapophyses of posterior thoracic and lumbar vertebræ with plane faces (except in horses).

Mesosternal segments broad and depressed.

Scapula without acromion (except in early horses) or metacromion.

Ulna greatly reduced in genera with enlarged digit III.

Carpus strongly interlocking, with scaphoid resting on magnum and lunar on unciform.

Fibula not articulating with calcaneum.

Distal end of astragalus flat, articulating with navicular and cuboid.

Digital reduction adaptive.

LITOPTERNA.

Upper molars imperfectly lophodont, posterior crest not formed.

Lower molars with pillar in posterior crescent (sometimes reduced).

No alisphenoid canal.

Tympanic scale-like.

Odontoid process always peg-like.

Zygapophyses of posterior thoracic and lumbar vertebræ semicylindrical.

Mesosternal segments mostly narrow and compressed.

Scapula with acromion and metacromion largely developed.

Ulna little reduced and proximally larger than radius.

Carpus semi-taxeopod, with scaphoid resting on magnum, but lunar not touching unciform.

Fibula articulating with calcaneum.

Distal end of astragalus depressed-convex, articulating with navicular only.

Digital reduction inadapative.

To my mind, the preponderance of evidence is thus decidedly in favor of the view that the Perissodactyla and Litopterna are no more closely related than two ungulate orders must necessarily be (if the monophyletic origin of the hoofed animals be a fact) and that resemblances between them are due to parallelism and not to genetic affinity. The primitive features of the Litopterna, such as the semi-taxeopod carpus and tarsus, extensive articulation between the fibula and calcaneum, and the inadapative method of digital reduction, are all as distinctly marked in the highly

specialized and monodactyl *Thoatherium* as in the tridactyl and isodactyl genera. When it is remembered that *Thoatherium* greatly surpasses the horses in completeness of digital reduction, the retention of so many primitive characters becomes all the more remarkable and significant.

The most important characteristics in which the Litopterna differ from the Perissodactyla are points of agreement between the former and the Toxodontia, most of which have tridactyl feet with mesaxonic symmetry. The principal difference between the Toxodontia and the Litopterna is in the structures of the auditory region, which, as Roth ('03) has pointed out, is very remarkably specialized in the former, but normal in the latter. To this question it will be necessary to return in the chapter dealing with the Santa Cruz fauna as a whole, but I may so far anticipate that chapter as to say that, in my judgment, despite this very striking and important difference, the Litopterna and Toxodontia "originated from a common ancestral stock," as Lydekker has expressed it.

PROTEROTHERIIDÆ.

The two families into which the Santa Cruz Litopterna are divided are sharply marked off from each other and represent two strongly divergent lines of development. The Proterotheriidæ are remarkable for the striking way in which they parallel and imitate the horses, especially in foot-structure, and they even surpass that perissodactyl family in the completeness with which the monodactyl foot is attained.

The Santa Cruz representatives of the present family are all of small or moderate size and most of them are slenderly built; none are massive or of great stature.

All of the Santa Cruz genera have the same dental formula: $I_{\frac{1}{2}}^1, C_{\frac{1}{1}}^0, P_{\frac{4}{4}}^1, M_{\frac{3}{3}}^2$. The single upper incisor is enlarged into a small, more or less trihedral and sharp-pointed tusk, growing from a persistent pulp; the outer lower incisor in all of the genera, except *Thoatherium*, is correspondingly enlarged. The lower tusk bites behind the upper, which is therefore worn on the posterior face. The median lower incisor is usually very small and of little or no functional importance, having no upper tooth opposed to it. The homologies of these incisors are not quite certain, but there is much reason to believe that, as in the toxodonts, they are the second upper and third lower of the original three (i_2^2 and i_3^3). The wide separation between the two upper tusks makes it almost certain that at least

one incisor has been lost from each premaxilla, and that the tusk is not i^3 is shown by two considerations: (1) In some individuals of *Thoatherium* a very small deciduous incisor is inserted in the premaxilla behind the temporary tusk; (2) the fact that the lower tusk bites *behind* the upper is evidence that the former is one degree farther back and therefore represents i^3 .

The upper canine is always absent and the lower, though present in all cases, is much reduced in size and can have had no functional significance.

The premolars are never altogether molariform, though p^4 approximates the molar pattern, and p^1 and rarely p^3 have that pattern quite completely. Though characteristically differing in the various genera, the upper molars are much alike throughout the family and have two well-defined, external, concave cusps, with two conical internal cusps and anterior and posterior conules. The transverse crests, especially the posterior one, are incompletely formed by the fusion of the internal cusps and the conules, and there is a tendency for all of these internal elements to become confluent and form an antero-posterior ridge. The varying extent to which this confluence is carried, forms one of the diagnostic features of the different genera. Where the tendency is least pronounced, as in *Diadiaphorus*, there is a certain resemblance to the molar-pattern of the Palæotheriidae, though differing in the absence of the posterior transverse crest, or metaloph.

The lower molars have the bicrescentic pattern so common in early and primitive families of both Artiodactyla and Perissodactyla, such as the Anoplotheriidae, Palæotheriidae, Titanotheriidae, etc., but often with the addition of the characteristic pillar in the concavity of the posterior crescent. This element, so general among the South American ungulates, is found in the Santa Cruz Proterotheriidae in varying stages of reduction; it may be quite conspicuous (*Licaphrium*), very minute and observable only in perfectly unworn teeth (*Proterotherium*), or entirely wanting (*Diadiaphorus*, *Thoatherium*). When present, this element is an isolated conical pillar, not connected with the outer wall by a transverse spur or ridge, as it typically is in the Macrauchenidae. The last lower molar may either be without any talon (*Thoatherium*, *Diadiaphorus*) or may have a very small one (*Proterotherium*), or a larger one (*Licaphrium*).

The skull has a moderately capacious and well rounded brain-case, with high and thin sagittal crest and orbits completely encircled with bone. The tympanic was so loosely attached that it has been lost from all the avail-

able skulls and probably, as in the *Macrauchenidæ*, was very small and did not form a bulla. The nasals are usually of normal length, articulating with the premaxillæ, but may be somewhat shortened, as in *Thoatherium*, or considerably so, as in *Diadiaphorus*. However, this reduction is never comparable to that in the *Macrauchenidæ*.

The neck is always remarkably short in comparison with the length of the limbs, and the cervical vertebræ have the vertebrarterial canal in the normal position, perforating the transverse processes. The odontoid process of the axis is always peg-like. The number of trunk-vertebræ is not definitely known, for no complete back-bone has yet been found, but a careful study of the available material renders it probable, that this number did not exceed 21-22, 14-15 thoracics and 7-8 lumbar. The posterior thoracic and lumbar vertebræ have semicylindrical, interlocking zygapophyses. The sacrum is long and tapers so much posteriorly, that the shortness of the tail is made quite certain, even in the absence of any known caudal vertebræ. The ribs are of the ordinary ungulate type, and the sternum has not yet been recovered.

The limbs are long and slender, but the feet, except in *Thoatherium*, are of only moderate elongation and the metapodials are usually short. The scapula is large and has a prominent metacromion and a small acromion, the two processes being quite near together, much nearer than in the *Macrauchenidæ*. The humerus is short and the fore-arm bones are always separate; the ulna is surprisingly little reduced, in view of the great degree of digital reduction attained in the family. The elongation of the fore-arm is not so great and that of the manus greater than in the *Macrauchenidæ*.

The pelvis has a decidedly equine appearance, though the division of the iliac plate into dorsal and ventral processes is less marked, and the tuberosity of the ischium is small in all of the genera in which the pelvis is known. The limb-segments have somewhat different proportions from those of the *Macrauchenidæ*, the femur being relatively less, and the tibia and pes more elongate. The femur has a strikingly equine character, which is due to the proportions of the head and shaft, the high, bluntly pointed great trochanter and the prominent third trochanter, which is larger than in the *Macrauchenidæ*. The tibia and fibula are always separate, though the latter is slender and much more reduced than the ulna, and the articulation with the calcaneum is retained in all the genera.

A highly characteristic feature of the Proterotheriidæ, which strongly distinguishes them from the Macrauchenidæ, is the structure of the feet. These are moderately elongate, except in *Thoatherium*, which has very long feet, and the elongation is largely due to the length of the phalanges, the metapodials being quite short. In both manus and pes the third digit is greatly enlarged and carries the whole weight of the body, while the second and fourth are very much reduced and either form dew-claws, or, in the case of the monodactyl *Thoatherium*, nothing remains of the lateral digits except vestiges of the proximal ends of the metapodials. This is a more complete degree of monodactylism than in any other known mammal. Thus, in all of the Santa Cruz genera of the family, the aspect of the feet is strikingly and surprisingly horse-like, a resemblance which is borne out by the very equine character of the ungual phalanges.

Despite this high degree of specialization, carpus and tarsus retain a very primitive structure, which is not only not in the least equine, but is not even perissodactyl. The carpus is almost taxepod, except that the scaphoid has extended over upon the magnum, the lunar having no contact with the unciform, from which it is excluded by the articulation, entirely lateral, between the magnum and pyramidal. The tarsus is equally primitive; the calcaneum has a large facet for the fibula and the astragalus is widely separated from the cuboid, articulating with the navicular by means of a convex head, which is less flattened than in the Macrauchenidæ. The method of digital reduction, which in all known perissodactyls, both fossil and recent, is according to the mode which Kowalevsky called "adaptive," is in the Proterotheriidæ "inadaptive." That is to say, the vestigial digits retain the carpal and tarsal connections which they originally had. A slight degree of adaptive modification may be observed in the tarsus of *Thoatherium*, but as compared with the pes of the less perfectly monodactyl horse, it is surprisingly incomplete.

Aside from certain imperfectly known and doubtful forms, the Santa Cruz Proterotheriidæ are divisible into four well-marked genera, distinguished by the following characteristics.

- A. Feet tridactyl; internal cusps of upper molars distinct; lateral lower incisor (i_3) much larger than median (i_2), which is very small.
 - I. Nasals much shortened; lower molars without pillar in posterior crescent; last molar without talon. *Diadiaphorus*.
 - II. Nasals of normal length; lower molars with pillar in posterior crescent; last molar with talon.

1. Teeth more massive ; upper premolars less differentiated ; upper molars with inner cusps partly connate ; pillar in posterior crescent of lower molars large ; animal stouter.
Licaphrium.
 2. Teeth with thinner cusps ; upper premolars more complex ; upper molars with inner cusps separate ; pillar of lower molars very minute and vestigial ; animal more slender.
Proterotherium.
- B. Feet monodactyl ; internal cusps of upper molars confluent ; lower lateral incisor (i_3) but little larger than median (i_2).
Thoatherium.

The mutual relationships of these four genera are reasonably clear. *Thoatherium* is in almost all respects much the most advanced and specialized and must have diverged from the others early in the history of the family. One primitive feature, the subequal size of the lower incisors, *Thoatherium* retains, and that this feature is really a primitive one, is rendered very probable by the fact that in the other genera the milk-incisors are of this type. *Proterotherium* and *Licaphrium* are very closely related and may be taken as the central line of the family ; the former is somewhat more advanced, as is shown in the more complex premolars and in the reduction of the pillar to vestigial proportions. In dentition, *Licaphrium* more nearly represents the primitive condition of the family than any of the other genera. *Diadiaphorus* is another divergent line, characterized by the complete loss of the pillar from the lower molars, and the notable shortening of the nasal bones, for most of the species also by a greater bodily stature.

DIADIAPHORUS Ameghino.

(Plates I-V ; XIII, Fig. 9.)

Diadiaphorus Amegh.; Enum. Sistemática, etc., 1887, p. 20.

Bunodontherium Mercerat ; Revista del Museo de La Plata, T. I, 1891, p. 450.

Oreomeryx Mercerat, in part ; Ibid., p. 465 (*fide* Ameghino).

This genus includes the largest representatives of the family which are found in the Santa Cruz beds, and is characterized (1) by the very complete separation of the internal cusps of the upper molars, which have nearly square crowns ; (2) by lower molars without talon, or postero-internal pillar ; (3) by the much shortened nasal bones.

Dentition (Pls. II, figs. 2-4 ; III, figs. 1-5, 8).

A. Upper Jaw. The single upper incisor is large and caniniform, somewhat recurved and acutely pointed ; it is of triangular cross-section, with

apex directed forward, and the posterior face is abraded by the lower lateral incisor.

A considerable diastema separates the incisor from the next succeeding tooth, p^1 . The premolars increase in size posteriorly, an increase which is sudden between p^1 and p^2 , and gradual behind that. The first premolar is quite small and implanted by two roots; the crown consists of a single external lobe, which has a cordate and slightly convex outer face, and a very low internal enamel ridge, or cingulum, which is divided by a median sulcus into anterior and posterior portions. The second premolar is very much larger and is inserted by three roots; the crown is formed essentially as in p^1 , but the external face has two convexities separated by a shallow median depression; the internal ridge is better developed and, in addition, there is an internal cingulum. The third premolar is still larger and almost molariform, but has only three roots, of which the internal one is very large; the external wall consists of two equal, concave cusps, which unite to form a median ridge, but has no distinct anterior or posterior style; the internal ridge is distinctly, but incompletely divided into three cusps, the deutero- and tetartocones and the anterior conule, the posterior conule being a minute pillar attached to the inner side of the postero-external cusp (tritocone); the cingulum varies in prominence and completeness. The fourth premolar is like p^3 , but larger, and the posterior conule is much better developed and the extremely large internal root shows signs of an incipient division into two.

The molar series is shorter than the premolar. The first and second molars have a similar pattern and differ only in size, m^2 being the largest of the series. The crown consists of two equal external lobes, the para- and metacones, with concave outer faces, which meet in a prominent meso-style, but, though the anterior and posterior borders are raised, there is no distinct para- or metastyle. The two internal cusps, proto- and hypocones, of which the former is somewhat the larger, are more or less conical, or pyramidal in shape: the anterior conule is connected with the antero-internal cusp (protocone), forming with it a very oblique transverse crest, but is demarcated from the antero-external cusp (paracone) by a deep, narrow, vertical cleft, while the posterior conule is a slender, isolated pillar, connected at the base with the postero-external cusp (metacone). From the postero-internal cusp (hypocone) runs a narrow prominent ridge, perhaps an elevated cingulum, to the hinder edge of the

metacone, enclosing a deep fossa with the posterior conule. The cingulum varies somewhat in development, but is always quite prominent on the antero-internal and inner sides, enclosing shallow fossæ before and behind the protocone, and ending upon the hypocone.

When in an advanced state of wear, the molar-pattern has quite a different appearance; an anterior, oblique, transverse crest, or protoloph, is formed by the protocone and anterior conule, which become connate with the paracone, and the posterior conule is confluent with the metacone, from which it forms a projection. Thus there is produced a certain similarity to the molar-pattern of *Palæotherium*, to which attention has often been called, but the absence of the posterior crest (metaloph) and the consequent irregular, S-shape of the valley are significant differences.

The third molar is the smallest of the series and is made asymmetrical by the reduction of the posterior half of the crown; the metacone is considerably smaller than the paracone and the hypocone is extremely small. All of the grinding teeth are closely appressed, so that the postero-external angle of each tooth actually notches the tooth behind it.

B. Lower Jaw. The median incisor (i_2) is a very small, simple and subconical tooth, which, to all appearance, can have been of little or no functional importance, for even in very old animals it shows hardly any sign of wear. The lateral incisor (i_3) is tusk-like, somewhat thinner and more compressed than the upper tusk, behind which it bites. The canine is very small and simple.

The first lower premolar (p_1) is much the smallest of the series and is inserted by a single root; the crown is simple and of elongate, compressed-conical shape, with cingulum well defined on the inner, but not on the outer side. The second premolar is of similar shape, but is very much larger and is carried upon two roots; the cingulum is prominent both internally and externally and on the inner side are two low ridges, enclosing shallow fossæ, of which the posterior is much the larger and deeper. The third and fourth premolars are molariform, but p_3 has a minute pillar on the inner side of the front end of the anterior crescent, and p_4 has a similar pillar on the hinder end of the posterior crescent.

The lower molars are much like those of *Anoplotherium*, *Palæotherium* and *Titanotherium* and are composed of two crescents, without accessory cusps or styles, but with prominent cingulum; m_3 has no talon or unpaired lobe. In entirely unworn teeth, minute vestiges of the postero-internal pillar may sometimes be observed in m_2 and 3 .

Milk Dentition.—The only example of the milk dentition which I have seen in this genus is a young skull without mandible or premaxillary region; all the milk-premolars are in place, as is also m^1 , while m^2 is visible in the jaw, but had not yet come into use. The temporary premolars closely resemble their successors both in size and in pattern, but in all of them the two internal cusps are more distinctly separated, and dp^3 and 4 , at least, are implanted by four roots, the internal pair of which differ from those of the true molars in being of more nearly equal size, though the posterior root is slightly larger than the anterior.

The *Skull* (Pls. II, figs. 1, 1a; IV, fig. 1) bears considerable resemblance to that of the North American Oligocene genus, *Merycoidodon* (*Oreodon*), though this resemblance is entirely superficial. The upper contour of the skull is a nearly straight line from the occipital crest to the tips of the nasals; the cranium is long, with moderately full brain-case, which, however, narrows much anteriorly; the face is short and the whole skull is deep dorso-ventrally in proportion to its length. The orbits, which are closed, are large and have a somewhat oblique position, so as to present slightly forward, as well as laterally. The sagittal crest is very prominent, especially posteriorly, where the roof of the brain-case slopes downward.

As a whole, the occiput is high and narrow; on the ventral half, above the foramen magnum, is a broad median convexity, with a shallow lateral fossa over each condyle; the dorsal half, which is extremely narrow, is concave. The occipital crest is very prominent in the dorsal region, dying away ventrally upon the paroccipital processes. These processes are long, very broad and laterally compressed, almost plate-like, tapering distally to a blunt point. The basioccipital is long and stout, with low and thin ventral keel; it is broadest about the middle of its course, narrowing slightly toward each end. The condyles, which are formed entirely by the exoccipitals, are rather small, but project prominently backward, and the foramen magnum is relatively small. The exoccipitals are wide and low, meeting in the median line; on each is a low, blunt process, the two separated by a deep median notch. The supraoccipital, which forms somewhat more than the dorsal moiety of the occiput, is high and narrow.

The periotic is exposed as a narrow strip in the deep, narrow cleft between the exoccipital and the squamosal; it does not form a mastoid process. The tympanic was not ankylosed with the periotic and was but loosely attached to the skull. I have seen no example of this bone, which is missing from all the skulls at my disposal.

The parietals are relatively long, extending forward to the postorbital constriction, where, on the dorsal side, they diverge to receive the posterior ends of the frontals. As already mentioned, the parietals support throughout their length a thin sagittal crest, which is low anteriorly and rises gradually behind, where it becomes very high. In this posterior region the parietals are pierced by several conspicuous vascular foramina. The squamosal extends well upward upon the side of the cranium, greatly narrowing the parietal in this region, but is widely separated from the frontal. The glenoid cavity is quite equine in character and may be described in the words which Flower ('85, 187) has applied to that of the horse; it is "greatly extended transversely, concave from side to side, convex from before backward in front and hollow behind." The only difference is that the anterior convexity is less prominent in the Santa Cruz genus. The postglenoid process is long, thick and spike-shaped, rhinocerotid rather than equine in character, but relatively shorter and more massive than in existing rhinoceroses. The posttympanic process, which is small, but well defined, is applied closely to the periotic and widely separated from the postglenoid. The zygomatic process is rather short, arching out boldly from the cranium; it is laterally compressed and thin, but quite broad dorso-ventrally, this breadth diminishing anteriorly as that of the jugal increases. The latter is elongate, extending posteriorly to the glenoid cavity and anteriorly to the lachrymal; the free portion is, like the zygomatic process, laterally compressed, but the suborbital portion is considerably thickened. The postorbital process is broad and prominent, but not very long; it unites suturally with the much longer process of the frontal. The lachrymal is large and considerably expanded upon the face, forming part of the inferior and almost all of the anterior wall of the orbit, and even some of the dorsal margin; it articulates with the jugal, maxillary and frontal, but is widely removed from the nasal; the foramen is quite large and entirely external in position, and the spine is a low tubercle.

The frontals are very large and form a broad, lozenge-shaped and nearly plane forehead; they are widest over the orbits, narrowing gradually to the sutures with the maxillaries and nasals, which form a nearly straight, transverse, though somewhat irregular line. The frontals expand very abruptly in front of the postorbital constriction and the temporal ridges, which diverge from the sagittal crest, take an almost transverse course;

from the hinder margin of each a low tubercle, or spine, projects into the temporal fossa. The postorbital process, which is long, broad and plate-like, has a somewhat twisted appearance, due to the fact that for most of its length the principal diameter is transverse, while at the distal end the principal diameter is antero-posterior. The foramen for the frontal artery is double and is placed rather more mesially than in the horse; another vascular foramen in each frontal is somewhat forward of and internal to the first and may be either single or double; from it a well defined groove passes forward to the nasal.

The nasals are very short, extending but a short distance over the premaxillaries, and quite broad behind; each is decidedly convex transversely, with a deep groove along the sutural line, and for some distance from the front end the two bones may be well separated. For nearly half their length, the nasals are not in contact with the maxillary and this free portion contracts rapidly to the blunt anterior point; the fore part of each nasal has a thin lateral border and a thick mesial border, making the bone triangular in cross-section.

The premaxillaries are quite rhinocerotid in shape; they are short, broad and heavy, with broad dorsal surfaces and short ascending processes, which do not reach the nasals; the palatine processes are relatively large, but the incisive foramina are small. The maxillary is very large; the sub-orbital portion is low, but the preorbital, or facial, portion is very high, especially in view of the entirely brachyodont dentition; a short process of the maxillary, between the premaxilla and the nasal, forms part of the boundary of the anterior nares; the small infraorbital foramen is situated far in advance of the orbit, above the anterior part of p^3 and is constantly double. The hard palate is long, narrow, contracting slightly forward, and deeply concave transversely. The palatines are rather small, extending to the posterior margin of p^3 , and the posterior palatine foramina are in the suture between the palatines and maxillaries. The posterior nares are also relatively small, with nearly parallel sides; the anterior border is opposite the middle of m^1 . The pterygoids, which are inconspicuous and early fuse with the alisphenoids, have no fossæ or hamular processes.

The cranial foramina are quite characteristic and do not entirely agree with those of either the artiodactyls or the perissodactyls. The optic foramen and foramen lacerum anterius are near together and are enclosed in a common, deep fossa; the latter foramen is very large, especially in

dorso-ventral diameter. There is no distinct foramen rotundum, the large foramen ovale, which is entirely within the alisphenoid, probably having transmitted both the second and third branches of the trigeminal nerve. No alisphenoid canal is present. Loss of the tympanic renders the eustachian foramen and foramen lacerum medium indistinguishable, but the course of the eustachian canal is probably indicated by a long, well-defined groove on the alisphenoid. The glenoid foramen is large and conspicuous. The foramen lacerum posterius notches the anterior border of the exoccipital, and the condylar foramen is almost concealed by the condyle, when the skull is viewed from below; it opens into a small, but deep and conspicuous fossa on the exoccipital.

The mandible has considerable resemblance to that of *Hyracodon*, a genus of rhinoceroses from the North American Oligocene; the two rami are coössified at the symphysis, which is narrow, of no great length and deeply concave on the dorsal side. The horizontal ramus is elongate, rather shallow dorso-ventrally, but quite thick and stout. The ascending ramus is rather broad and quite high, the condyle being raised well above the level of the teeth; the angle, which is regularly rounded and thin, projects prominently behind the condyle, with convex external and concave internal face; the masseteric fossa is quite small, but well defined, and is situated very high upon the ascending ramus, reaching from the condyle to the level of the alveolar border. The condyle is sessile, so that there is no definite sigmoid notch, and is much extended transversely, especially toward the inner side; on the posterior face of the condyle, near the inner end, is a considerable facet, which articulates with a corresponding surface on the postglenoid process. The coronoid is high, rising much above the condyle and, when the jaws are closed, projecting above the zygomatic arch; it is thin, but moderately broad and is either erect, or inclined slightly forward. The inferior dental foramen is situated behind and a little below m_3 , and there is a large mental foramen on each side below the canine or p_1 .

Vertebral Column and Ribs (Pl. I).—In no individual of the Proterotheriidae has a complete series of vertebræ been found, as yet. There is, however, reason to believe that the formula was as follows: C. 7, Th. 15, L. 6–7, S. 6, Cd.?. In one specimen belonging to the American Museum (No. 9290), the neck is preserved with all the vertebræ in place and 15 trunk vertebræ are also present. The neck is decidedly short and quite

stout and, as in all this family, is in very marked contrast to that of the *Macrauchenidæ* both in length and in the form of the individual vertebræ.

The atlas (Pl. IV, figs. 2, 2a) is relatively rather long, as well as high dorso-ventrally; the anterior cotyles are large, widely separated dorsally, but closely approximated at the ventral ends; the neural canal is large and subcircular, the neural arch is thick and quite broad in both directions, without spine. The transverse processes are narrow, having hardly more than half the fore-and-aft extension of the atlas and there is, of course, no atlanteo-diapophysial foramen; the processes have a very elevated position and ventral to them there is a deep fossa on each side of the vertebra. The very short vertebrarterial canal perforates the base of the transverse process.

The axis (Pl. IV, fig. 3) has a moderately elongate, broad and very much depressed centrum, with prominent ventral keel; the cotyles for the atlas are low and wide and have somewhat saddle-shaped faces; the odontoid process is short, blunt and massive and is separated from the cotyles by a deep sulcus on each side; the facet for the inferior arch of the atlas is very strongly convex, extending more than half-way around the odontoid. The neural canal is rather small and the pedicles of the neural arch are quite narrow antero-posteriorly; the neural spine is a large, prominent, hatchet-shaped plate, which projects well over the third vertebra and is very different from the long, low ridge seen in *Theosodon*. The vertebrarterial canal is of large diameter, but short, and pursues an oblique course, from behind, upward and forward through the base of the transverse process.

The third cervical has a short and somewhat opisthocœlous centrum, and a low, broad neural arch, without spine, for nearly half of its antero-posterior length is overhung by the spine of the axis, leaving no room for one on the third vertebra. The transverse process is a large, oblique plate, short transversely, but much extended antero-posteriorly, especially forward, where it overlaps the centrum of the axis. The fourth cervical is so like the third as to call for no particular description, further than to note that it has a slightly smaller and more slender centrum. The three remaining cervicals have centra which progressively decrease in length, though only to a moderate degree, shorter neural arches, which are more deeply incised between the postzygapophyses, and an increasing development of the spines. On the fifth cervical the spine is still very incon-

spicuous; it is much more prominent on the sixth and still more on the seventh. The transverse processes are much less extended antero-posteriorly than on the preceding vertebræ, but appear to be wider transversely.

As already pointed out, the neck as a whole is short, which is also true of all of the known Santa Cruz representatives of the family. Taking the basal length of the skull as 100, that of the neck is 72.2, as nearly as can be calculated from the material now available.

The number of trunk vertebræ (Pl. I) is not definitely known, but it is highly probable that this number was 21 or 22. Of these 15 were probably thoracic, and it is certain that there cannot have been less than 6 lumbar. Assuming that there were fifteen thoracic vertebræ, their combined length, measured around the ventral curve of the spinal column, may be calculated as approximately 136, the basal length of the skull being 100.

The first thoracic vertebra has a broad, much depressed centrum, with well defined ventral keel; the prezygapophyses are of the cervical type, while the postzygapophyses have the thoracic pattern and are placed on the ventral side of the neural arch; the neural spine is not very high and is quite slender, with a moderate inclination backward; the transverse processes are heavy and prominent and bear large facets for the ribs. After an interval of perhaps four vertebræ, not represented in the collections, follows a series of four in their natural connection. These have rather small, slightly depressed and somewhat opisthocœlous centra, of the ordinary ungulate type, and slender neural spines which are strongly inclined posteriorly. In the figure of the skeleton (Pl. I) this inclination does not appear so marked, because of the oblique position of the centra in this part of the column. The transverse processes are quite prominent and arise high up on the sides of the neural arch.

In the posterior part of the thoracic region the centra are larger than in the median portion and quite broad and depressed; the zygapophyses are cylindrical and interlocking, very much like those typical of the Artiodactyla, and the metapophyses are very prominent. The short transverse processes still arise from the neural arches rather than from the centra; even on the last thoracic these processes have facets for the rib-tubercles. The neural spines, which are rather low, are thin transversely, plate-like and broad antero-posteriorly. The penultimate thoracic is the anticlinal vertebra, the neural spine of the last one having a distinct forward inclination.

The lumbar formula in *Diadiaphorus* is 6-7 though not more than six

of these vertebræ have been found in association with any one individual. The lumbar (Pl. IV, figs. 4-5) have elongate and rather narrow centra, which are but moderately depressed; they are quite sharply constricted in the middle and have low, sharp ventral keels; only in the last vertebra does the centrum become notably broad and low. The neural canal is quite small and the neural spines are relatively short, with a strong forward inclination; transversely these spines are much compressed and thin, antero-posteriorly they are broad at the base, narrowing to the tip; the zygapophyses are cylindrical and interlocking, as in the posterior thoracic region, and the metapophyses are very prominent. On most of the lumbar the transverse processes are long, depressed, tapering and antroverted, but on the last two they are short and very broad, becoming on the last one broader than the antero-posterior diameter of the centrum and forming a pair of exceedingly large plates; on the anterior border of each process is a well-defined articular facet for a corresponding surface on the transverse process of the penultimate lumbar, and on the hinder border a still larger one for the first sacral.

The sacrum consists of six vertebræ, of which only the first two support the ilium; the centra diminish in size posteriorly, becoming very small in the last three vertebræ, as does also the neural canal. None of the sacral vertebræ has a neural spine, but the metapophyses of the last four are connected by high, continuous ridges, making this region transversely concave: the neural arches are not everywhere continuous, but leave a median vacuity between each successive pair of vertebræ. On each transverse process of the first sacral is a large convexity, which articulates with the concave facet on the transverse process of the last lumbar, as already described.

No caudal vertebræ of this genus have yet been identified, but, from the small size of the last sacral and the great reduction in the diameter of its neural canal, it is evident that the tail must have been short.

A few fragments show that the ribs are laterally compressed and plate-like and, though not very broad, they are of the usual ungulate character.

Nothing is yet known of the sternum.

Appendicular Skeleton.—The skeleton of the limbs and feet is very fully known. The scapula (Pl. I) is known, as yet, in only two genera of this family, *Diadiaphorus* and *Proterotherium*, and, though the bone is quite different in shape in these two genera, there are no structural differ-

ences of importance. In *Diadiaphorus* the blade is high, narrow and of subquadrate outline, and across it the prominent spine pursues an oblique course, dividing it into two nearly equal, triangular areas. Of these, the anterior, or prescapular fossa is wider distally, while the postscapular fossa is wider proximally. The neck is broad, especially the portion in front of the spine, and the glenoid cavity is a simply concave oval, with the antero-posterior diameter somewhat exceeding the transverse. The coracoid is a large and rugose, but not conspicuous, rounded tubercle. There is a distinct, though shallow, coraco-scapular notch, above which the coracoid border is strongly convex and curves gradually into the suprascapular border. In the only available specimen of the scapula of *Diadiaphorus* the postero-superior portion is broken away, but the strongly inclined course of so much of the glenoid border as is preserved, indicates that the proximal portion of the postscapular fossa was very broad.

The spine is prominent and recurved, making the anterior surface convex and the posterior concave. There is a single, well-developed metacromion, which is much more distal in position than that of the *Macrauchenidæ*; the acromion itself is broken and may not have been continued distally, but, nevertheless, stands out very prominently from the neck. This is in marked contrast with the *Perissodactyla*, in which the spine dies away gradually upon the neck.

No trace of a clavicle has been found in this or any other representative of the *Litopterna*.

The humerus (Pl. IV, figs. 6, 6a) is short and stout, with large head projecting prominently behind the plane of the shaft; the great tuberosity is high and the deltoid ridge is very long, extending down more than half the length of the shaft, upon which it dies away gradually, not forming any prominence or hook. The distal trochlea is rather narrow and of very simple form, without division into separate facets, and the internal border has a very prominent flange for the ulna. Both the anconeal and the supratrochlear fossæ are small, but deep, and are connected by an irregular perforation; the external epicondyle is distinct, while the internal one is obsolete, but the postero-internal angle of the distal end is a prominent rugosity, somewhat as in the horse; the supinator ridge is distinct, though not prominent.

The fore-arm bones are quite short in relation to the humerus and are in contact for most of their length, making but a short and narrow radio-

cubital arcade. The radius (Pl. IV, figs. 7, 7*a*) is relatively slender; its head, though occupying the whole width of the humeral trochlea, is not broad, and has a transversely oval, antero-posteriorly compressed shape; on the inner side of the head is a small, oblique facet, which abuts against the internal flange of the humeral trochlea; this facet is continuous with the proximal articular surface, which is composed of a low internal convexity and a very shallow external concavity. The proximal ulnar facet is very small and is confined to the postero-internal side of the head. On the internal side of the shaft, just below the head, is the large and rugose, but low, bicipital tubercle. The shaft is moderately arched forward and inward and is of transversely oval cross-section, broadening slightly to the distal end. The distal end is quite heavy, with a single broad and shallow tendinal sulcus on the dorsal surface; there is a small facet for the ulna on the external side. The facets for the scaphoid and lunar are sharply demarcated by a ridge and are concave dorsally, becoming convex toward the palmar side; the lunar facet is reflected farther upward upon the palmar aspect of the bone than is that for the scaphoid.

In view of the degree of digital reduction in the manus, which is functionally all but monodactyl, the ulna (Pl. IV, fig. 8) is surprisingly large and heavy, relatively quite as stout as in the tapir. The olecranon is well developed and is much thickened and rugose at the free end; it projects upward and backward, extending well behind the plane of the shaft; the coronoid process is very prominent and the sigmoid notch quite deep, though short proximo-distally, its articular surface is continuous, but distally the external portion is produced considerably farther, extending around the head of the radius, for which it has a small facet. The shaft is strongly arched forward and very heavy, of subtriangular cross-section and contracting slightly to the distal end. The distal facet for the radius is a small, but prominent oval convexity; the pyramidal facet is relatively large and simply convex, while that for the pisiform is exceedingly small.

As Ameghino has shown (94*b*, p. 266) the manus (Pl. V, figs. 1, 1*a*, 1*b*, 3, 4) has undergone a remarkable degree of reduction and bears a striking, though entirely superficial, likeness to that of one of the three-toed horses, such as *Protohippus*, for example. The carpus is not at all equine, or even perissodactyl, in character and may be defined as semi-taxeopod, the scaphoid articulating with the magnum, but the lunar not coming into contact with the unciform. In the carpo-metacarpal connections, this

manus is an excellent example of what Kowalevsky has called the "inadaptive" method of reduction in the Artiodactyla.

The scaphoid is a large, nearly cubical bone; its proximal end is covered by the radial facet, which is convex on the dorsal, concave on the palmar side; distally, it articulates with the trapezium, trapezoid and magnum; the facet for the trapezium is small, that for the trapezoid is the largest of the three and deeply concave, while the articulation with the magnum is quite extensive and is made by a process which descends below the level of the trapezoid facet.

The lunar is quite large, exceeding the scaphoid in proximo-distal length; the radial facet consists of two parts, a dorsal portion, which is broad, convex and oblique, rising quite steeply toward the ulnar side, and a much narrower palmar extension, which is saddle-shaped. Distally, the lunar rests entirely upon the magnum and is very widely separated from the unciform.

In proximo-distal diameter, the pyramidal is much the longest of the carpal elements, almost equalling the combined lunar and magnum in length, but in width and thickness it is considerably inferior to the scaphoid; the ulnar facet is of moderate size and slightly convex, and is continuous with that for the pisiform, which is narrow, oblique and slightly saddle-shaped. Distally, the bone is covered by a large, concave facet for the unciform, while on the radial side of the distal end is a large surface for the magnum, which is an unusual arrangement in an ungulate carpus.

In the present genus the pisiform is still unknown.

In view of the tridactyl and functionally monodactyl character of the manus, the trapezium is quite large; it is of an irregularly polygonal shape, with the maximum diameter directed proximo-distally, and is so displaced toward the palmar side as to be almost invisible when the manus is seen from the front: the trapezium articulates with the scaphoid, trapezoid and second metacarpal. The trapezoid is not very much larger than the trapezium and, like the latter, its principal diameter is the proximo-distal one: proximally it has a slightly convex facet for the scaphoid and on the ulnar side are two facets, for the scaphoid and magnum respectively, which meet at a very open angle; distally, the trapezoid articulates only with mc. II.

In correlation with the great enlargement of mc. III, the magnum is much the largest bone of the distal row, but is quite unlike that of the horses in shape, being longer proximo-distally and narrower transversely

than in that phylum : the proximal end is divided unequally between the scaphoid and lunar facets, the latter being somewhat the smaller of the two : on the radial side are two nearly equal facets for the trapezoid and mc. II ; the distal facet for mc. III is convex and oblique, rising toward the ulnar side, on which is a relatively large, concave surface for the pyramidal : there is no articulation with the unciform.

The unciform, though considerably larger than the trapezoid, is yet much smaller than the magnum : it is narrow, thick and moderately elongate proximo-distally : in correlation with the great length of the pyramidal, the unciform projects much farther distally than any of the other carpals, its proximal surface being below the distal end of the trapezoid. Consequently, as already noted, there is no contact between the magnum and unciform, the radial side of the latter being covered by the process of mc. III : on the distal end is a concave facet for the head of mc. IV and, palmar to this, a small surface for the rudimentary mc. V.

The metacarpus is tridactyl and mesaxonic and, though the lateral digits have their full complement of phalanges, they are mere dew-claws and can have had little or no functional importance. Ameghino states ('94*b*, p. 268) that in this genus there is a vestigial mc. I, which is quite long and extremely slender and is placed on the palmar side of the manus. I have seen no example of this.

Metacarpal II is much shorter and very much more slender than mc. III ; the proximal end is relatively heavy and quite extensively overlaps the head of mc. III and abuts against the radial side of the magnum, thus entirely excluding mc. III from any contact with the trapezoid. The shaft is slender, much compressed laterally, but of considerable dorso-palmar diameter, and has a strong forward curvature ; the distal trochlea is very narrow, but has a well-defined carina, which is reflected over upon the dorsal face of the trochlea.

Metacarpal III is very stout and moderately elongate ; the proximal end is supported only by the magnum, for though there is quite an extensive articulation with the unciform, this contact is entirely lateral. On the other hand, the overlapping head of mc. II, by means of which part of the weight is transmitted from the radius through the scaphoid and trapezoid to mc. III, may be regarded as functionally equivalent to another carpal element. On the ulnar side, mc. III hardly projects at all over the head of mc. IV. The shaft is heavy, palmo-dorsally compressed and broad

transversely, increasing in width toward the distal end; for nearly half its length, the shaft has on each side a broad, shallow depression, to receive the lateral metacarpals; on the dorsal side, near the radial border of the proximal end, is a prominent tubercle for the attachment of the extensor tendon. The distal trochlea is broad and very low proximo-distally, but has a very prominent carina, which extends around the entire dorsal face of the trochlea, quite as in the horses.

Metacarpal IV is the counterpart of mc. II: proximally, it is overlapped but little by the head of mc. III and articulates with the unciform by means of a slightly convex facet.

A vestige of metacarpal V is attached to the unciform and mc. IV, and is a very small, almond-shaped bone, ending distally in a blunt point.

The phalanges of the lateral digits are small, slender, laterally compressed and resemble quite closely those of *Protohippus*: the unguals are pointed and somewhat irregularly shaped. On the contrary, the phalanges of the median digit are greatly elongated, together exceeding the metacarpal in length, and have a marked resemblance to those of the horses. The proximal phalanx is especially long and is also broad, but is much depressed palmo-dorsally: the proximal end is very broad and has a shallow, concave trochlea, deeply grooved in the median line to receive the metacarpal carina, which, however, does not notch the dorsal border of the trochlea. Below the proximal end the shaft at first narrows rapidly, then more gradually, broadening again somewhat at the distal end: the distal trochlea is very low and saddle-shaped, concave transversely and convex palmo-dorsally.

The second phalanx is short and broad; the proximal end is quite thick in the dorso-palmar dimension, but this thickness diminishes rapidly and the distal end is strongly depressed: the proximal trochlea is a single transverse groove, without such intercondylar ridge, or division into two facets, as may be seen in the horses: the distal trochlea also lacks the median groove of the equines and is more depressed. The ungual phalanx is exceedingly like that of such three-toed equine genera as *Protohippus*; it is broad, depressed, with rounded free border and conspicuous median cleft at the distal end: the proximal trochlea is an undivided transverse groove, and the lateral processes are moderately well developed: the palmar surface is slightly concave, with a deep crescentic concavity near the proximal end.

Despite its resemblance to that of the horses, the manus of *Diadiaphorus* is fundamentally different. In the carpus we find a retention of semi-taxeopod conditions, in that the lunar is far removed from the unciform and rests entirely upon the magnum. The carpals of the distal row, especially the magnum, are much narrower than in the equine manus, while the large, functional third metacarpal supports only the magnum, not extending, even on the palmar side, beneath the unciform on one side and the trapezoid on the other, as it so conspicuously does in the horses, and the second metacarpal retains its full connection with the magnum. As compared with that of the horses, the metacarpal of the median digit is relatively short, while the phalanges of this digit are very elongate. In brief, the Santa Cruz genus, despite its markedly advanced degree of specialization in foot-structure, yet retains a surprising number of primitive characteristics.

Like so many other elements of the appendicular skeleton, the pelvis (Pl. I) has a decidedly equine appearance. The ilium has a shorter and much broader peduncle, which expands anteriorly into a broad plate of very similar shape to that of the horses, with median portion sharply curved upward, to articulate with the sacrum, much as in the horse, but the external portion has no such heavy crista as in the latter: the iliac surface is very broad and the ilio-pectineal process is prominent and projects almost directly inward. The acetabulum has a prominent border, which anteriorly becomes very heavy and rugose; it is extensively invaded from the ventral side by a large and deep sulcus for the round ligament. The ischium is rather short and slender and its dorsal ramus is trihedral, flattening posteriorly into a strongly everted plate; the tuberosity is a conspicuous, but rather slender spine-like process. The pubis is short, stout and much depressed, and forms a long symphysis with its fellow of the opposite side. The obturator foramen is relatively quite small and of irregularly oval shape.

Of all the bones in the skeleton, the one which is most strikingly horse-like in character is the femur (Pl. III, fig. 6). The head is quite small, and of depressed and somewhat irregular shape, and sessile; the pit for the round ligament is a V-shaped incision on the postero-internal side of the head, much like that of the horse in shape and position, but smaller and shallower. The great trochanter is very large, rising high above the head, but less massive than in *Equus*, and not divided by a sulcus into two parts, as it is in the horses; the digital fossa is large and deep: the

second trochanter is a compressed conical tuberosity, prolonged distally into a ridge; the third trochanter is prominent, though rather small, and has a more distal position than in *Equus*: the shaft is long, quite slender and laterally compressed. All of the femora certainly referable to the present genus, which I have seen, are so injured that the pit for the plantaris muscle is not shown, but as this fossa appears in all the other genera of the family, it was doubtless present in *Diadiaphorus* also. The trochlea is asymmetrical, with the inner border decidedly more prominent than the outer, and the suprapatellar fossa is deep: the condyles are quite small, projecting but little behind the plane of the shaft, and are asymmetrical, the external one being larger and more convex than the internal: there are no distinct tuberosities.

The patella is strikingly different from that of *Theosodon*, being short proximo-distally, broad, very thick, and rugose on the anterior surface, while the articular facet for the femoral trochlea is quite small.

As in all of the Santa Cruz representatives of the Litopterna, the leg-bones (Pl. III, fig. 7) are separate. The tibia is quite stout and somewhat shorter than the femur; the condyles are widely separated, making a bifid spine: the cnemial crest is prominent and very heavy proximally, but extends only a short distance down the shaft and terminates abruptly, and the sulcus for the tendon of the *extensor longus digitorum* is much shallower than in *Equus*. The shaft is stout, almost straight and of subtriangular section, becoming transversely oval near the distal end, which is somewhat broadened and thickened: the astragalar surface is divided into two unequal facets, of which the internal is the larger, by an intercondylar ridge, which projects as a prominent tongue on both dorsal and plantar sides, and is especially heavy on the latter; the dorsal tongue bears an articular surface for the pit on the neck of the astragalus; the internal malleolus is much reduced.

The fibula is far more reduced than the ulna: the shaft is straight, slender, laterally compressed and of irregularly trihedral shape; near the distal end it becomes quite thick antero-posteriorly, but remains narrow transversely: on the external side of the distal end is a very deep sulcus for the peroneal tendon, the borders of which groove are thickened and form tubercles distally. The distal facet for the tibia is small and confluent with the large plane surface for the astragalus; the calcaneal facet is relatively large and quite complex, being composed of an anterior convexity and a posterior concavity.

Like the manus (Pl. V, figs. 2, 2*a*), the pes has a striking, but essentially superficial resemblance to that of the horses, the tarsus being even more radically different from the perissodactyl type than is the carpus.

The astragalus is more artiodactyl than perissodactyl in character, though sufficiently unlike the former group; it is narrow and elongate and has a deeply grooved trochlea, which is slightly asymmetrical, owing to the somewhat larger size of the external condyle: the neck is long, especially on the tibial side, ending in quite a broad, depressed and convex head for the navicular, but there is no contact with the cuboid, which is widely removed from the astragalus. The external calcaneal facet is large and so oblique as to have a lateral rather than a plantar presentation; the sustentacular facet has quite an artiodactyl appearance, being long and gently convex proximo-distally, and becoming confluent with the navicular facet, but is not of uniform width, broadening regularly to the distal end: a small third facet for the calcaneum is on the outer side of the head. The navicular facet is broad and convex, and, toward the fibular side, is reflected well over upon the dorsal side of the neck, so that the proximal border of the facet descends steeply from the fibular to the tibial side.

The calcaneum is long and is remarkable for the elongation of the portion distal to the fibular facet: the tuber is much compressed laterally, thick planto-dorsally, and has nearly parallel borders; the free end is thick and rugose, but has no tendinal sulcus, such as occurs in the Artiodactyla; the fibular facet is narrow, but quite elongate proximo-distally, and is made up of a posterior convexity and an anterior concavity; the external astragalar facet is large, convex and oblique, presenting inward more than dorsally. The sustentaculum is prominent and thick and its articular surface is continued for some distance upon the body of the calcaneum, extending to the third astragalar facet. On the tibial side, below the last named facet, is an articular surface for the navicular. As already observed, the distal portion of the calcaneum is very long and laterally compressed, and together with the prominent fibular facet, gives a somewhat artiodactyl appearance to the bone; the cuboid facet is deeply concave planto-dorsally and oblique transversely, descending steeply toward the fibular side.

The navicular is broad and also relatively elongate proximo-distally, strikingly so as compared with the flattened, disc-like navicular of the horse: from the plantar face is given off a very long and heavy hook-like process: the astragalar facet is slightly concave transversely, deeply so in the dorso-

plantar direction, with the plantar border raised much higher than the dorsal. The distal end is almost entirely occupied by the very large facet for the ectocuneiform, which surface is also slightly concave planto-dorsally: the facet for the middle cuneiform is extremely small and that for the internal one is entirely lateral, or postero-lateral in position.

The entocuneiform is a large, flattened, scale-like bone, which is so far displaced to the plantar side as hardly to be visible when the pes is seen from the front, and its connections are entirely lateral, with the navicular, mesocuneiform and second metatarsal respectively. The mesocuneiform is extremely small, with nearly square dorsal face; it likewise is much displaced toward the plantar side and articulates only with mt. II, not touching mt. III at all. The ectocuneiform is very large, much the largest bone of the distal row, and nearly equals the navicular in size; it has, as compared with that of the horses, considerable proximo-distal diameter, and thus helps materially in making up the great length of the tarsus, which is so striking a feature of this pes. Transversely, the proximal border is concave and the distal convex.

The cuboid is quite small, especially in width, the length on the plantar side being considerable and the thickness planto-dorsally being much the greatest of its diameters, which is due to the large and massive, though not elongate, hook-like process from the plantar side: the proximal surface for the calcaneum is saddle-shaped, concave and very oblique transversely, convex planto-dorsally; the distal end has a small, plane facet for mt. IV and, internal to this, a small oblique surface for mt. III.

The metatarsals resemble the metacarpals in size and proportions and in their inadaptable method of reduction. Metatarsal II is very much like mc. II; the proximal end bears a small facet for the mesocuneiform and on the plantar side another for the entocuneiform; it does not overlap the head of mt. III and apparently has no contact with the ectocuneiform, though I cannot satisfy myself entirely on this point. Metatarsal III bears the whole weight of the limb and is supported only by the ectocuneiform, the limited contact with the cuboid being obliquely lateral, and there is no articulation with the mesocuneiform. As a whole, the bone closely resembles mc. III, but is somewhat thicker planto-dorsally, and the process from the plantar side of the proximal end is much longer and more slender. In all of the specimens which I have examined mc. III is of nearly the same length as mt. III. Ameghino's figures ('94*b*, pp. 266-7, figs. 8-9) make

mt. III longer, but he does not state that manus and pes were derived from the same individual. Metatarsal IV is very like the corresponding metacarpal and its proximal end is hardly at all overlapped by that of mt. III.

The phalanges resemble those of the manus, but those of the functional digit III are somewhat longer, more slender, more depressed and flattened, while the ungual is decidedly longer, narrower and more pointed than is that of the manus.

Restoration (Pl. I). — The chief difficulty in the way of making a satisfactory restoration of *Diadiaphorus* is the uncertainty as to the number of trunk-vertebræ, which, of course, has an important effect in determining the appearance and proportions of the animal. In general appearance, the skeleton of *Diadiaphorus* bears considerable resemblance to that of *Hyracodon*, the lightly built, cursorial rhinoceros from the Oligocene of North America, though an immediately obvious difference is the much shorter neck of the Santa Cruz genus. The head is relatively rather small, though deep and heavy dorso-ventrally, and the very short nasals are especially characteristic of this genus. The neck is short, hardly equaling three-quarters of the basal length of the skull, and quite slender, which is due to the small size of the vertebræ and the shortness of the neural spines, save that of the axis.

For reasons that have been sufficiently explained in the foregoing pages (p. 10), it has been assumed that the number of trunk-vertebræ was 21, of which 15 have been assigned to the thoracic and 6 to the lumbar region. The back appears to have been nearly straight, without hump at the shoulders, and with rather short and slender spines. The thorax was probably long and the loins rather short. The caudal vertebræ are still quite unknown, but from the character of the sacrum it is evident that the tail was short.

The limbs are moderately elongate and slender and resemble much those of the three-toed horses, such as *Protohippus*. The humerus is rather short and the fore-arm bones, which remain separate, are somewhat longer. Femur and tibia, on the other hand, are of nearly the same length. The tridactyl feet are also elongate, but this elongation is largely due to the length of the phalanges, carpus and tarsus, the metapodials being relatively much shorter than in the horses. Though the feet have three complete digits each, only the median digit touches the ground, while the laterals are mere dew-claws.

DIADIAPHORUS MAJUSCULUS Ameghino.

(Plates I; II, Figs. 1, 1a, 2; III, Figs. 4-7; IV; V; XIII, Fig. 9.)

D. majusculus Amegh.; Enum. sistemática, etc., 1887, p. 20.*D. diplinthus* Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 298.*Bunodontherium majusculum* Mercerat; Revista del Museo de La Plata, T. I, 1891, p. 454.*B. patagonicum* Mercerat; Ibid., p. 453 (*fide* Ameghino).*Oreomeryx Rutimeyeri* Mercerat; Ibid., p. 469 (*fide* Ameghino).

This is by far the commonest and best known representative of the genus and the only one of which any considerable part of the skeleton has been recovered: consequently, the diagnosis of this species, as of the others, must be drawn principally from the teeth.

In *D. majusculus* the upper caniniform incisor is moderately heavy and is followed by a long diastema. In the upper molars the posterior conule is placed close to the postero-external cusp and separated by a deep cleft from the postero-internal, so that even in well worn teeth the posterior fossa still communicates with the median valley. The postero-external cusp of m^3 is reduced in size to a degree which varies somewhat in different individuals. The development of the internal cingulum on the upper teeth is subject to considerable individual variation and does not afford a trustworthy criterion for the discrimination of species.

In the lower jaw, the small median incisors are separated by short interspaces from each other and from the caniniform laterals, which are quite large and but moderately divergent. The canine is isolated by very short diastemata in front of and behind it and the second premolar has a fore-and-aft position parallel with the axis of the jaw.

In the following table No. 1 is a cast of the type specimen of *D. diplinthus*; No. 9291 is a very perfect skull and mandible in the American Museum of Natural History, and No. 9270, of the same collection, comprises a large part of the skeleton of an old and rather small individual, perhaps a female, while No. 15,799 is the most complete skeleton in the Princeton Museum.

MEASUREMENTS.

	No. 1.	No. 15,799.	No. 9291.	No. 9270.
Upper dentition, length		.156	.150	.145
Upper incisor, antero-posterior diameter		.009	.009	
“ “ transverse diameter		.007	.007	

	No. No. 1.	No. 15,799,	No. 9291.	No. 9270.
Diastema between i^3 and p^1		.027	.024	.027
Upper premolar-molar series, length		.119	.118	.109
“ premolar series, length		.0635	.063	.056
P^1 , length (<i>i. e.</i> , antero-posterior diameter)		.012	.0125	.012
“ width (<i>i. e.</i> , transverse diameter)		.0105		.009
P^2 , length		.016	.015	.014
“ width		.018		.015
P^3 , length	.0165	.017	.017	.015
“ width	.0185	.020		.018
P^4 , length	.018	.020	.018	.015
“ width	.020	.021		.020
Upper molar series, length		.0583	.058	.053
M^1 , length	.019	.0205	.018	.017
“ width	.022	.023		
M^2 , length		.0235	.023	.019
“ width	No.	.025		.0235
M^3 , length	9196.	.019	.018	.017
“ width		.022		.021
Lower dentition, length		.140	.1515	.143
$I_{\frac{3}{8}}$, greater diameter	.0085	.009	.008	
“ lesser “	.0065	.006		
Lower premolar-molar series, length	.109	.125	.121	
“ premolar series, length	.054	.062	.062	
$P_{\frac{1}{2}}$, length	.009	.0096	.010	
“ width	.005	.006		
$P_{\frac{2}{2}}$, length	.014	.015	.014	
“ width	.0095	.0085		
$P_{\frac{3}{2}}$, length	.015	.019	.017	
“ width	.012	.011		
$P_{\frac{4}{2}}$, length	.016	.019	.018	
“ width	.014	.0125		
Lower molar series, length	.055	.063	.059	
$M_{\frac{1}{2}}$, length	.016	.018	.017	
“ width	.0135	.014		
$M_{\frac{2}{2}}$, length	.019	.021	.020	
“ width	.014	.0155		
$M_{\frac{3}{2}}$, length	.0205	.0215	.022	
“ width	.010	.013		
Skull, length from occipital condyles to premaxilla incl.			.238	.239
Cranium, length to anterior edge of orbit			.140	.139
Face, length orbit to premaxilla	.111		.101	.108
“ dorso-ventral height at m^1			.070	
Occiput, height			.075	.075

	<i>No.</i> 9196.	<i>No.</i> 15,799.	<i>No.</i> 9291.	<i>No.</i> 9270.
Occiput, width at base			.057	.064
Sagittal crest, length			.097	.108
Zygomatic arch, length			.101	
Skull, width over zygomatic arches			.123	.125
" interorbital width			.080	.085
Nasals, length in median line			.054	
Mandible, length		.223	.214	
" height at condyle		.107	.081	
" " coronoid			.110	
" depth at m_3	.034	.040	.035	
" " p_3	.026	.028	.025	
" length of symphysis	.048	.040	.045	

N. B. The apparent discrepancies in the tooth-measurements are due to the overlapping of the teeth.

	<i>No.</i> 9196.	<i>No.</i> 15,799.	<i>No.</i> 9270.
Atlas, length		.052	.054
" width over anterior cotyles		.055	.053
Axis, length of centrum		.044	.044
" width of anterior end			.048
" length of odontoid		.017	
" width " "		.0125	
5th cervical, length of centrum		.028	
" " width of anterior face		.021	
1st thoracic, length of centrum		.022	.026
" " width of anterior face		.023	
" " " over transverse processes		.062	
?4th lumbar, length of centrum		.034	.036
" " width of anterior face		.025	.023
" " height to end of spine		.060	
?6th " length of centrum		.0315	.034
" " width of anterior face		.0265	.024
" " " over transverse processes		.078	
Sacrum, length		.128	
1st sacral, width of anterior face		.023	
Last sacral, length		.015	
" " width of posterior face		.0085	
Humerus, length from head		.177	.176
" distal width over epicondyles		.0425	.043
" width of trochlea		.0265	.027
Radius, length		.171	
" width of proximal end		.026	
" " " distal end	.025	.029	

	<i>No.</i> 9196.	<i>No.</i> 15,799.	<i>No.</i> 9270.
Ulna, length		.200	
“ “ of olecranon		.053	
“ width at sigmoid notch		.027	
“ “ of distal end	.013	.014	
Carpus, length in median line		.025	
“ greatest width		.037	
Metacarpal II, length	.080		
“ “ width of proximal end	.010	.010	
“ “ “ “ distal end	.008		
“ III, length	.092	.093	
“ “ width of proximal end	.023	.025	
“ “ “ “ distal end	.027	.030	
“ IV, length	.075		
“ “ width of proximal end	.006	.007	
“ “ “ “ distal end	.008		
Digit II, phalanx 1, length	.020		
“ “ “ 1, proximal width	.0095		
“ “ “ 2, length	.010		
“ “ “ 2, proximal width	.008		
“ “ “ 3, length	.013		
Digit III, phalanx 1, length	.047	.052	
“ “ “ 1, proximal width	.025	.029	
“ “ “ 1, “ thickness	.015	.015	
“ “ “ 1, distal width	.020	.022	
“ “ “ 1, “ thickness		.011	
“ “ “ 2, length	.020	.025	
“ “ “ 2, proximal width	.023	.027	
“ “ “ 2, distal width	.014		
“ “ “ 3, length		.0355	
“ “ “ 3, proximal width	.0325	.033	
“ “ “ 3, “ thickness	.010	.012	
Femur, length from head		.224	
“ “ “ great trochanter		.238	
“ width of proximal end		.061	
“ “ “ distal end over condyles	.048	.051	
“ “ “ rotular groove	.028	.032	
Tibia, length (exclusive of spine)		.198	.193
“ proximal width		.050	.049
“ distal width	.027	.035	.032
“ “ thickness	.027	.036	.032
Fibula, distal width		.006	.006
“ “ thickness	.020	.022	.021

	No. 9196.	No. 15,799.	No. 9270.
Tarsus, length from external astragalar condyle	.060	.068	
“ greatest width	.031	.036	
Astragalus, length	.039	.044	.044
“ width of trochlea	.022	.026	.024
“ length of neck on fibular side	.011	.013	.013
Calcaneum, length		.088	.086
“ “ of tuber		.044	.043
“ width of free end		.021	.018
“ “ “ distal end		.011	.012
Ectocuneiform, length in median line	.0115	.011	.011
“ width	.0205	.022	.023
Metatarsal II, length	.072	.078	
“ “ proximal width		.0055	
“ “ “ thickness	.013	.015	
“ “ distal width	.007	.008	
Metatarsal III, length	.092	.092	.094
“ “ proximal width	.024	.026	.024
“ “ distal width		.027	.0255
Metatarsal IV, length	.071		
“ “ distal width	.0075		
Pes, digit III, phalanx 1, length	.049		
“ “ “ “ 1, proximal width	.024		
“ “ “ “ 1, distal width	.0205		
“ “ “ “ 2, length	.0195		
“ “ “ “ 2, proximal width	.022		
“ “ “ “ 2, distal width	.020		
“ “ “ “ 3, proximal width	.028		
“ “ “ “ 3, “ thickness	.011		
Pes, digit IV, phalanx 1, length	.020		
“ “ “ “ 1, proximal width	.008		
“ “ “ “ 2, length	.009		
“ “ “ “ 2, proximal width	.0063		

The proportions of these two specimens (Nos. 9196 and 9270) differ so much as to suggest that they belong to different species, possibly even to different genera: No. 15,799, on the other hand, agrees well with Ameghino's figures.

Localities.—No. 15,799 was collected by Mr. Peterson on the Patagonian coast, ten miles south of Coy Inlet: No. 9196 (A. M. N. H.) was obtained by Mr. Brown, thirty miles south of Santa Cruz.

DIADIAPHORUS ROBUSTUS Ameghino.

(Plate III, Figs. 1-3.)

D. robustus Amegh.; Énum. Synopt. des Mamm. Foss. de Patagonie, 1894, p. 47.

D. majusculus Lydekker, in part; Anales del Museo de La Plata, T. II, 1893, p. 59.

D. cælops Amegh.; Anales del Museo Nacional de Buenos Aires, Ser. 3, T. III, p. 477.

This species, which is not represented in the Princeton or the New York collections, is known to me only from a cast of the type-specimen and from Lydekker's figure ('93, Pl. XXIV, fig. 2). These indicate an animal of about the same size as *D. majusculus*, but rather more robust. The upper tusk is considerably stouter and is followed by a shorter diastema; in m^1 and 2 the posterior conule is placed so near to the postero-internal cusp as almost to block the connection between the posterior fossa and the median valley, so that, in a comparatively early stage of wear, the fossa is isolated as an enamel lake. In the lower jaw the small median incisors are separated from each other but are in contact with the large, tusk-like laterals, which are very strongly divergent. The canine follows the lateral incisor without a diastema, and the first premolar is pressed against the canine and implanted obliquely to the long axis of the jaw. Naturally, one is tempted to regard this species merely as the male of *D. majusculus*, but the differences in the upper molars can hardly be of a sexual nature.

In the table, No. 83 is a cast of the type of *D. robustus* and No. 85 of the type of *D. cælops*.

MEASUREMENTS.

	No. 83.	No. 85.
Upper dentition, length	.148	
“ incisor, greater diameter	.011	
“ “ lesser “	.010	
“ premolar-molar series, length	.118	
Diastema between i^2 and p^1	.019	
Upper premolar series, length	.0625	
P^1 , length (<i>i. e.</i> , antero-posterior diameter)	.013	
“ width (<i>i. e.</i> , transverse diameter)	.0105	
P^2 , length	.0155	
“ width	.017	
P^3 , length	.017	
“ width	.0205	

	No 83.	No 85.
P ⁴ , length	.018	
" width	.023	
Upper molar series, length	.056	
M ¹ , length	.0205	.0205
" width	.025	.025
M ² , length	.022	
" width	.028	
M ³ , length	.017	.018
" width	.025	.024
Lower dentition, length	.140	
" tusk, greater diameter	.0095	
" " lesser diameter	.0075	
" premolar-molar series, length	.124	
" premolar series, length	.063	
P ₂ , length	.015	
" width	.008	
P ₃ , length	.0185	
" width	.012	
P ₄ , length	.018	
" width	.014	
Lower molar series, length	.061	
M ₁ , length	.018	
" width	.014	
M ₂ , length	.021	
" width	.013	
M ₃ , length	.020	
" width	.011	

Localities. — Not given for type of *D. robustus* or for that of *D. callops*.

DIADIAPHORUS VELOX Ameghino.

(Plates II, Figs. 3, 4; III, Fig. 8.)

Diadiaphorus velox Amegh.; Enum. sistemática, etc., 1887, p. 20.

Of this, the smallest known species of *Diadiaphorus*, I have seen no upper teeth. According to Lydekker ('93, p. 60), "the upper molars are somewhat smaller than those of *D. majusculus* and of much more brachyodont type, the valleys being shallower and more open and the columns lower." Lydekker's figures (*op. cit.*, Pl. XXV, figs. 7, 8) show that in this species the upper grinding teeth are broader transversely in proportion to their antero-posterior length than in the preceding species. Further, this author says that "the associated lower molars show a small tubercle in

the posterior crescent." Such an association is almost certainly an accidental one of *Proterotherium* or *Licaphrium* with *D. velox*.

For the mandibular dentition, I have two individuals, one the cast of a jaw in the Ameghino collection, marked "co-type," the other (No. 15,295) in the Princeton collection. Between these two specimens there are some striking differences, principally in the form of the caniniform incisor and in the relative size of the molars. It may well be that we have here to do with different species, but until more complete material has been obtained, I shall prefer to consider the differences as sexual and to regard the Princeton mandible as belonging to a female.

In the co-type the caniniform i_3 is broad and thin and the canine is placed nearly midway between i_3 and p_1 , while in the supposed female the tusk is more slender and conical and very much less compressed, and the canine is inserted somewhat nearer to i_3 than to p_1 . The grinding teeth resemble those of the preceding species, except for their smaller size and slightly greater relative width. Both of the mandibles indicate animals somewhat smaller than the type of the species.

As will be noted from the table, the molars are considerably larger in No. 15,295 than in the co-type.

MEASUREMENTS.

	Co-type.	No. 15,295.
Lower dentition, length	.096	
I_3 , greater diameter	.007	.0055
" lesser "	.003	.005
Lower premolar-molar series, length	.074	.079
" premolar series, length	.039	.039
P_1 , length (<i>i. e.</i> , antero-posterior diameter)	.005	.006
" width (<i>i. e.</i> , transverse diameter)	.004	.004
P_2 , length	.010	.010
" width	.005	.005
P_3 , length	.011	.011
" width	.008	.008
P_4 , length	.011	.011
" width	.010	.010
Lower molar series, length	.036	.041
M_1 , length	.0105	.012
" width	.009	.010
M_2 , length	.0115	.013
" width	.009	.010
M_3 , length	.012	.015
" width	.0075	.008

Localities. — The type-specimen was found in "the cliffs of the Santa Cruz River"; No. 15,295 was collected by Mr. Peterson on the coast of Patagonia, ten miles south of Coy Inlet. The field label says: "base of Santa Cruz beds."

LICAPHRIUM Ameghino.

(Plates VI; VII, Figs. 1-7a.)

Licaphrium Amegh.; Enum. sistemática, etc., 1887, p. 20.

Anisolophus Mercerat, in part; Rev. del Museo de La Plata, T. I, 1891, p. 462.

There may be some doubt as to the propriety of separating this genus from *Proterotherium*, for, although typical specimens of the two are quite strikingly different, transitions between them are not wanting. Yet, as there is no certainty that these transitional forms are all strictly contemporaneous, it would serve no useful purpose to unite the two genera. *Licaphrium* may be distinguished by the following characteristics: (1) The animal is relatively heavier and more robust and the teeth are more massive than in *Proterotherium*. (2) The internal ridge of p^2 is not divided into cusps, while p^3 and p^4 have no tetartocone. (3) In the upper molars the two internal cusps are less distinctly separated and in m^2 they are actually connected by an enamel ridge; in m^3 the hinder half of the crown is less reduced and in some of the species there is a small, but distinct hypocone. (4) In the lower jaw, the molariform premolars and the molars have shallower and less defined valleys and in the molars the postero-internal pillar is much larger than in *Proterotherium*, while the talon of m_3 is not so clearly separated from the posterior crescent. (6) The limb bones are heavier and the feet shorter and thicker.

Dentition (Pls. VI, figs. 1a, 1b, 3-5; VII, figs. 2-7a).

Upper Jaw. The incisor has the same caniniform, tusk-like shape as in *Diadiaphorus* and *Proterotherium*. Of p^1 I have seen no unworn specimens; when well abraded, it resembles that of *Proterotherium*, while p^2 differs from the type usual in the latter genus in not having the internal ridge divided into two cusps. The third and fourth premolars, though nearly molariform, differ somewhat from each other; p^3 is smaller, has much smaller conules, less prominent anterior and posterior cingulum, and a minute, incipient tetartocone, which is absent in p^4 . Both of these teeth are thus distinctly less advanced in differentiation than those of *Pro-*

terotherium. The molars are broad and heavy, with thick, massive cusps: in m^1 , and especially in m^2 , the internal cusps are less distinctly separated than in *Proterotherium* and in m^2 these cusps are connected by a low ridge of enamel. The third molar differs from that of the last named genus in having the hinder half of the crown less reduced and, in several of the species, a distinct, though very minute hypocone is present: m^3 closely resembles p^4 .

Lower Jaw. The incisors do not differ in any noteworthy manner from those of *Proterotherium*, except that they tend to be more procumbent. The canine is small and, in most instances, is placed in contact with the lateral incisor, but is sometimes separated from it by a very short space. The first premolar is usually larger than in *Proterotherium* and $p_{\bar{2}}$ resembles that of the latter in form, but has less prominent internal ridges; $p_{\bar{3}}$ is almost molariform, but the anterior crescent has a shallower valley and is less complete than the posterior, and the antero-internal cusp is a partly separated pillar. In $p_{\bar{4}}$, which is quite molariform, the antero-internal pillar is much reduced or absent, but the postero-internal one is well-developed, though varying in degree of separateness.

In the typical species of *Licaphrium*, such as *L. floweri*, the lower molars differ from those of *Proterotherium* in their breadth and massiveness and in the shallowness of their valleys, especially in the anterior crescents, but in *L. proximum*, the proportions are much more nearly as in the latter genus. A constant difference, however, is to be noted in the much larger size of the postero-internal pillar, which is always very conspicuous, and the talon of $m_{\bar{3}}$ is less distinctly separated from the posterior crescent.

Comparatively little is known of the skeleton. I have seen no complete example of the skull (Pls. VI, fig. 1; VII, fig. 1), but, so far as it is preserved in the available specimens, it has great resemblance to that of *Proterotherium*, but is heavier and more massive and the bones composing it are much thicker. The occiput is broader than in *Diadiaphorus*, narrowing less dorsally. The face is short and very deep dorso-ventrally, though this proportion varies much in the different species. The orbit has a somewhat lower position than in the last named genus, and in front of the orbit the dorsal part of the maxillary has a curiously inflated appearance, doubtless owing to an enlargement of the antrum. This swollen appearance is most conspicuous in old animals. The lachrymal foramen is placed a little in front of the orbital rim, as in *Diadiaphorus*; the infra-

orbital foramen is larger than in the latter and is constantly double. The material is insufficient for fully determining the character of the nasals and anterior nares, but it is clear that these structures are intermediate in form between *Diadiaphorus* and *Proterotherium*. The nasals are longer than in the former and articulate with the premaxillæ, of which the depressed and rounded sheath of the tusks are shorter, and consequently, the narial opening is less oblique.

The mandible has a very stout horizontal ramus, which in some species is unusually deep dorso-ventrally, increasing this diameter of the face.

I have seen no vertebræ of this genus, except two thoracics belonging to *L. floweri* (A. M. N. H., No. 9271), evidently the penultimate and last of the region. These vertebræ resemble the lumbar of *Diadiaphorus*, and have large, depressed centra, cylindrical, interlocking zygapophyses, with prominent metapophyses, and low, broad neural spines. On the penultimate vertebra the spine is erect, showing that this is the anticlinal, while on the last it has a slight forward inclination. Both have short, though prominent, transverse processes and even the last one articulates with the tubercle of the rib.

Bones of the limbs and feet (Pl. VI, fig. 2), so far as they are known, resemble those of *Diadiaphorus*, but are relatively somewhat more elongate.

LICAPHRIUM FLOWERI Ameghino.

(Plates VI, Fig. 3; VII, Figs. 1-4.)

Licaphrium floweri Amegh.; Enum. sistemática, etc., 1887, p. 20.

Licaphrium intermedium Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 297 (typographical error).

Licaphrium intermissum Amegh.; Ibid., p. 345.

Anisolophus Fischerei Mercerat; Rev. del Museo de La Plata, T. I, 1891, p. 465 (*fide* Ameghino).

Licaphrium granatum Amegh.; Énum. Synopt. des Mamm. Foss. de Patagonie, 1894, p. 41.

This is the typical and one of the largest, heaviest and most abundant species. Most of the specimens found are of very old individuals, with teeth so worn that almost all trace of the tooth-pattern has been obliterated. However, one of the Ameghino series of casts, marked "co-type," shows m^2 and 3 in a moderately abraded condition. According to this specimen, m^3 has a metacone which is but little reduced in size, though quite oblique

to the plane of the paracone. Apparently there is no trace of the postero-internal cusp, or hypocone, the posterior cingulum curving upward at a right angle upon the posterior edge of the protocone, the inner side of which is strongly convex.

The lower molars are very broad and heavy, with massive cusps and shallow valleys, especially of the anterior crescents; the postero-internal crescent is thick and blunt, and the talon of m_3 large.

In the following table No. 33 is the co-type already referred to; No. 34 is a cast of a mandible referred to this species; No. 36 is a cast of the type of *L. granatum* and No. 39 is also a cast referred to the same species. No. 9271 is the facial portion of the skull of a very old individual, in the collection of the American Museum of Natural History; the small size of the tusks indicates that this was probably a female.

MEASUREMENTS.

	No. 33.	No. 34.	No. 36.	No. 39.	No. 9271.	No. 15,309.
Upper dentition, length					.128	
“ incisor, greater diameter					.008	
“ “ lesser “					.006	
“ premolar-molar series, length					.091	
“ premolar series, length					.047	
P^2 , length (<i>i. e.</i> , ant.-post. diameter)					.012	
“ width (<i>i. e.</i> , transverse diameter)					.0135	
P^3 , length					.013	
“ width					.016	
P^4 , length					.014	
“ width					.017	
Upper molar series, length					.044	
M^1 , length					.013	
“ width					.019	
M^2 , length					.016	
“ width					.022	
M^3 , length					.014	
“ width					.021	
Lower lateral incisor, greater diameter.		.007		.009		
“ “ “ lesser “		.005		.0055		
Lower premolar-molar series, length		.096	.097	.101		
“ premolar series, length		.048	.049	.051		
P_T , length				.010		
“ width				.005		
P_2 , length		.014		.013		

	No. 33.	No. 34.	No. 36.	No. 39.	No. 9271.	No. 15,309.
P ₂ , width		.006		.007		
P ₃ , length		.016		.015		
" width		.011		.011		
P ₄ , length		.014	.014	.014		.014
" width		.013	.013	.013		.013
Lower molar series, length		.048	.047	.050		.051
M ₁ , length		.014	.0145	.015		.0145
" width		.012	.014	.014		.014
M ₂ , length		.015	.015	.0165		.0165
" width		.013	.014	.014		.0145
M ₃ , length		.017	.0175	.0185		.020
" width		.0115	.0115	.013		.0125
Mandible, depth below m ₃						.033
" " " P ₄						.023

It may be well to add here the measurements of the supposed *L. intermissum* Amegh., which I believe should be referred to this species; they are taken from casts of the type.

MEASUREMENTS.

Upper premolar-molar series, length	.086	Lower premolar series, length	.048
" premolar series, length	.050	P ₁ , length	.010
P ₁ , length (<i>i. e.</i> , ant.-post. diam.)	.010	" width	.004 ⁷⁵
" width (<i>i. e.</i> , transverse diameter)	.007	P ₂ , length	.012
P ₂ , length	.0113	" width	.005
" width	.012	P ₃ , length	.014
P ₃ , length	.0125	" width	.0085
" width	.018	P ₄ , length	.014
Upper molar series, length	.038	" width	.012
M ₁ , length	.019	Lower molar series, length	.044
" width	.036	M ₁ , length	.013
M ₂ , length	.013	" width	.0115
" width	.021	M ₂ , length	.013
M ₃ , length	.012	" width	.012
" width	.020	M ₃ , length	.017
I ₃ , greater diameter	.008	" width	.0105
" lesser diameter	.0045	Mandible, depth below m ₃	.033
Lower premolar-molar series, length	.092	" " " P ₄	.024

It is made plain by the measurements that this individual is somewhat smaller than most examples of *L. floweri*, but not sufficiently so to require its separation as a distinct species, and the teeth are all so abraded that

no peculiarities of pattern are visible. That the animal was a female, is perhaps indicated by the very thin lower tusk.

In *L. floweri* the cranium is not known. The facial region (Pl. VIII, fig. 1) is short and of remarkable dorso-ventral depth; taking the length of the upper dentition as 100, this depth, measured from the alveolar border of m^2 upward, is 59.3, while in *Diadiaphorus majusculus* this proportion is only 43.6, being actually as well as relatively less in the latter. The skull, with the mandible, must have had something of the same square, heavy outline in side view as is found in *Hyracodon*. The frontal sinus and antrum together form a large, convex surface in front of and above the orbit. The nasals are broad and strongly convex from side to side; their full length is not preserved, but the portion remaining is actually longer, and therefore proportionately much longer, than in *Diadiaphorus majusculus*; they also differ from the latter in having an articulation with the premaxillæ, which appears to be relatively shorter than in *Proterotherium*, and the rounded, depressed alveolar sheath of the tusk-incisor is also shorter than in some species of the latter. As in all of the Santa Cruz members of the family, the palatine processes of the premaxillæ are small, those of the maxillaries extending forward between the very broad ascending rami of the former to the incisive foramina. The anterior narial opening is high and narrow, with moderate backward inclination, and the posterior opening is very far back, with front border between the second molars.

All of the mandibles are unfortunately incomplete, lacking the angle, coronoid and condyle. The horizontal ramus is notably stout, thick in all parts and very deep dorso-ventrally in the posterior part, where the alveolar border and tooth-row curve upward; anteriorly the ramus becomes shallower and the symphysial region is procumbent.

Associated with this skull fragment are the two thoracic vertebræ previously described, the astragalus, calcaneum and third metatarsal. Except for their smaller size and slightly more slender proportions, these bones display hardly any tangible difference from those of *Diadiaphorus majusculus*, except that the proximal part of mt. III is distinctly more compressed planto-dorsally and that the plantar surface is broader than in the latter.

MEASUREMENTS.

Face, length orbit to premaxillary	.105	Astragalus, length of neck on fib-	
“ dorso-ventral depth at m ²	.076	ular side	.015
Penultimate thoracic, length of cen-		Calcaneum, length	.081
trum	.031	“ “ of tuber	.043
Penultimate thoracic, width of ante-		“ width of free end	.016
rior face	.023	“ “ “ distal end	.011
Last thoracic, length of centrum	.032	Metatarsal III, length	.084
“ “ width of posterior face	.025	“ “ proximal width	.024
Astragalus, length	.041	“ “ distal width	.025
“ width of trochlea	.023		

Localities.—The type of the species was found in the cliffs of the Santa Cruz river, but no locality is given for the types of *L. granatum* or *L. intermissum*. No. 9271 (A. M. N. H.) was collected by Mr. Brown at Mantas Casa, 7 miles south of the Coy River; No. 15,309 by Mr. Peterson 20 miles south of Coy Inlet.

LICAPHRIUM PYRAMIDATUM Ameghino.

(Plate VI, Figs. 4, 5.)

Licaphrium pyramidatum Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 472.

This species is known to me only from casts of the type-specimen, fragments of the maxillary and mandible, each with the four last teeth in place. In size and proportions of the teeth this species agrees closely with *L. floweri*, but there are certain differences in the pattern which justify the separation. In m³ the postero-external cusp (metacone) is more reduced in size and the single internal cusp (protocone) is larger and has a plane internal face, giving a characteristically pyramidal shape; the conules, especially the posterior one, are smaller. The lower grinding teeth have less massive cusps and more open valleys, and in m₃ the postero-internal pillar and talon are more slender, giving quite a different appearance to the tooth.

MEASUREMENTS.

P ⁴ , length (<i>i. e.</i> , ant.-post. diam.)	.0145	M ² , width	.022
“ width (<i>i. e.</i> , transverse diameter).	.020	M ³ , length	.014
Upper molar series, length	.047	“ width	.022
M ¹ , length	.0155	P ₄ , length	.014
“ width	.020	“ width	.0125
M ² , length	.0175	Lower molar series, length	.051

MEASUREMENTS.

M ₁ , length	.015	M ₂ , width	.013
" width	.012	M ₃ , length	.020
M ₂ , length	.016	" width	.012

Locality. — Not given.

LICAPHRIUM PROXIMUM Ameghino.

(Plate VII, Figs. 6-7a.)

Licaphrium proximum Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 469.

Of this species I have seen only the casts, which I owe to the kindness of Dr. Ameghino. The type-specimen is a fragment of the right maxillary containing m¹ and ² and accompanying it is a separate m³ of the left side; the second specimen is part of the right ramus mandibuli, with all the molars and the last two premolars in place. Assuming that these are all properly referable to the same species, the distinctness of that species is indisputable. The third upper molar resembles that of *L. pyramidatum* in having the protocone flattened on the inner side, but differs in the presence of a minute, but distinct hypocone, which is but partly detached from the prominent posterior cingulum.

The lower teeth differ from those of the other species of *Licaphrium* and resemble those of *Proterotherium* in their proportions, in the lack of massiveness of the cusps and in the deep and widely open valleys. At the same time, the propriety of referring this species to *Licaphrium* is made evident by the very large size of the postero-internal pillar and by the talon of m₃. All of the teeth preserved, with the exception of m₃, have very broad posterior crescents, which bulge outward over the roots in a very characteristic way.

MEASUREMENTS.

M ¹ , length (<i>i. e.</i> , ant.-post. diam.)	.014	P ₄ , width	.0095
" width (<i>i. e.</i> , transverse diameter)	.019	Lower molar series, length . .	.043
M ² , length	.016	M ₁ , length	.012
" width	.0205	" width	.010
M ³ , length	.0135	M ₂ , length	.014
" width	.0215	" width	.011
P ₃ , length	.0155	M ₃ , length	.0165
" width	.009	" width	.0095
P ₄ , length	.013		

Locality. — Not given.

LICAPHRIUM PYNEANUM sp. nov.

(Plate VI, Figs. 1-2.)

Among the fossils collected by Mr. Hatcher at Lake Pueyrredon is the incomplete skull and mandible of a *Licaphrium*, different from any that has yet been described. Associated with the skull are the femur, tibia and part of the pes. The remains are those of a young animal, with almost unworn teeth; the premolars are all in place, but the last molar, above and below, was just in process of eruption and not yet in use. Actually, the teeth are of nearly the same size as in *L. floweri* and are therefore considerably larger in proportion to the size of the skull. In no other specimen of the genus have I seen perfectly unworn examples of p^2 and 3 and am therefore unable to make an exact comparison of these teeth in the different species. In p^2 the transverse diameter is relatively somewhat less than in *L. floweri* and the other preceding species: it has a single, large, cordate external cusp and a low, ill-defined internal one; the inner cingulum forms two discontinuous loops, of which the anterior curves backward to the apex of the deuterocone, while the posterior one curves forward inside of the latter, extending beyond the end of the anterior loop, but quite widely separated from it transversely.

The third upper premolar has a more nearly square crown than in *L. floweri* and the inward projection of the antero-internal portion is much less prominent; the conules are small, especially the posterior one. Anteriorly the cingulum is a low, broad shelf, the inner end of which curves backward and dies away against the base of the deuterocone, while the posterior cingulum is much more elevated and rises to join the apex of the deuterocone. A minute, incipient tetartocone arises from this cingulum; I am unable to say whether this minute cusp is present in other species of the genus, but its variability is shown by the fact that, in the individual before us, it is more distinct on the right side than on the left.

The fourth upper premolar, like p^3 , has a more nearly square crown than in *L. floweri* and, in particular, the inward production of the antero-internal portion is less, so that the tooth has a more symmetrical outline: the conules are larger and more conical than in p^3 and the posterior cingulum is separated by a cleft from the deuterocone. On the right side, there is no tetartocone, as in the other species of the genus, but on the left side, there is an extremely feeble indication of it.

The first and second upper molars have been badly broken and the principal difference from those of the other species which may still be noted is their relatively less transverse width. The third molar is proportionately larger than in the other species and has a less reduced metacone, though the external face of this cusp is very oblique; the protocone is large and appears to have a convex internal face; the hypocone, though small, is much more distinct than in *L. proximum*, being almost separated from the cingulum, which passes around it.

All of the lower teeth in front of p_3 are broken away level with the jaw; the lateral incisor, which is very large and procumbent, would seem to indicate that the animal was a male. The last two premolars and the molars have broad and heavy crowns, but the cusps are less massive and the valleys much deeper and better defined than in *L. floweri*, but less so than in *L. proximum*. On all of the lower molars the postero-internal pillar is extremely large and prominent and, as in *L. proximum*, it is largest in m_2 , while in *L. floweri* it is largest in m_3 : the talon of m_3 is smaller than in either of the species named.

MEASUREMENTS.

P^2 , length (<i>i. e.</i> , ant.-post. diam.) .	.013	$I_{\frac{3}{8}}$, lesser diameter	.0055
" width (<i>i. e.</i> , transverse diameter) .	.013	Lower premolar-molar series, length .	.099
P^3 , length	.014	" premolar series, length .	.052
" width	.017	$P_{\frac{3}{8}}$, length	.015
P^4 , length	.0145	" width	.010
" width	.018	$P_{\frac{4}{8}}$, length	.015
Upper molar series, length . . .	.043	" width	.0115
M^1 , length	.015	Lower molar series, length . . .	.047
" width	.019	M_I , length	.0145
M^2 , length	.0165	" width	.012
" width	.020	$M_{\frac{2}{8}}$, length	.017
M^3 , length	.0165	" width	.0145
" width	.014	$M_{\frac{3}{8}}$, length	.017
$I_{\frac{3}{8}}$, greater diameter	.011	" width	.018

The skull (Pl. II, fig. 1) has a long cranium, with full and rounded brain-case; the temporal ridges and sagittal crest are much as in *Diadiaphorus*, but the crest is much thicker. Though the dorsal moiety of the occiput is badly broken, it is plain that it was relatively broader than in *Diadiaphorus* and even somewhat wider than in *Proterotherium*. Apparently, the periotic is entirely excluded from the surface of the skull by the

junction of the squamosal and occipital. The basioccipital is long and broad, with median convexity, which bears a ventral keel, and shallow concavities on the sides. On each side of the basioccipital is a very large vacuity, which was partly closed by the missing tympanic. The basisphenoid is long, broad behind, tapering forward, so that the anterior end is very narrow. The posterior nares extend farther forward than in *L. floweri*, to the middle of m^2 .

One of the most striking differences of this species from *L. floweri* is the comparative shallowness, dorso-ventrally, of the facial region, even making all due allowance for the vertical crushing which the skull has undergone. In fact, this proportion approximates that found in *Proterotherium*. The supra-orbital foramen, which is single on each side, is very large.

The horizontal ramus of the mandible is thick and stout, but shallower dorso-ventrally than in *L. floweri*, thus making still more marked the difference between the two species in the vertical diameter of the skull.

MEASUREMENTS.

Cranium, length to anterior rim of orbit	.126	Face, depth at m^2	.056
Occiput, width at base	.054	Mandible, depth at m_3	.029
		" " " p_1	.022

The femur is very similar to that of *Diadiaphorus*; the head is small, sessile and deeply notched on the inner side by the triangular sulcus for the round ligament. The great trochanter is very prominent and, though not rising so high above the head as in *Diadiaphorus*, is broader and more recurved on the posterior side: the other trochanters are broken away. The shaft, which has a very decided sigmoid curvature, is much compressed laterally, thick antero-posteriorly; the pit for the plantaris muscle is very deep and conspicuous.

The tibia is somewhat shorter than the femur and quite stout; the cnemial process, though very prominent and with massive proximal end, is shorter than in *Proterotherium*, dying away more abruptly upon the shaft. Of the distal end, the width slightly exceeds the thickness; the astragalar facets are not deeply concave, despite the prominence of the intercondylar ridge, the dorsal tongue of which is somewhat better defined than in *Proterotherium*. Except near the dorsal side, to which the very low internal malleolus is confined, the astragalar facet has no raised inner margin.

The tarsus (Pl. VI, fig. 2), so far as it is preserved, does not differ in any important manner from that of *L. floweri*; the distal end of the calcaneum has a somewhat narrower and less oblique facet for the cuboid.

Metatarsal III is somewhat shorter than in *L. floweri* and relatively rather broader and more compressed planto-dorsally, and more flattened on the plantar side. The phalanges of this digit resemble those of *Diadiaphorus*, except that the proximal one is thicker and has on its dorsal face a more prominent tubercle for the extensor tendon.

MEASUREMENTS.

Femur, length from head . . .	.192	Mt. III, length	.082
“ “ “ grt. trochanter. . . .	.205	“ “ distal width	.025
“ proximal width	.058	Digit III, phalanx 1, length . . .	.044
“ distal width	.048	“ “ “ 1, proximal width	.0285
Tibia, length (exclusive of spine) .	.175	“ “ “ 1, distal width	.020
“ distal width	.031	“ “ “ 2, length	.018
“ “ thickness	.027	“ “ “ 2, proximal width	.024
Astragalus, length	.0385	“ “ “ 2, distal width	.021
“ width of trochlea	.021		

Locality.—The type-specimen was collected by Mr. Hatcher on the west shore of Lake Pueyrredon.

This species is named in honor of M. Taylor Pyne, Esq., Litt.D., to whose liberality the Patagonian Expeditions are much indebted.

LICAPHRIUM PARVULUM Ameghino.

(Plate VII, Fig. 5.)

Licaphrium parvulum Amegh.; Enum. sistemática, etc., 1887, p. 20.

Licaphrium arenarum Mercerat; Rev. del Museo de La Plata, T. II, 1891, p. 460 (*fide* Ameghino).

The type of this species is a single tooth (m_3), measuring 15×8 mm., which is distinguished by its small size and by the prominence of its talon. A cast of another specimen, a fragment of the maxillary with the three molars, kindly sent me by Dr. Ameghino, shows that m_3 is of the type of *L. pyramidatum*, on a smaller scale, the posterior cingulum curving up to join the apex of the single, large internal cusp. The mandibular teeth which accompany this second specimen are, without doubt, referable to *Proterotherium*. The cast has the following dimensions.

MEASUREMENTS.

Upper molar series, length	.038	M ² , width	.019
M ¹ , length (<i>i. e.</i> , ant.-post. diam.)	.013	M ² , length	.013
“ width (<i>i. e.</i> , transverse diameter)	.018	“ width	.020
M ² , length	.014		

SPECIES INCERTÆ SEDIS.

The two following species, which have been referred to *Licaphrium*, are not sufficiently well known to make clear their generic reference.

LICAPHRIUM DEBILE Ameghino.

Licaphrium debile Amegh.; Énum. Synopt. des Mamm. Foss. de Patagonie, 1894, p. 42.

LICAPHRIUM TENUÆ Ameghino.

Licaphrium tenuæ Amegh.; Ibid., p. 43.

This is the smallest known Santa Cruz representative of the family, but, further than to say that it is not a species of *Thoatherium*, it is not possible to go with the existing material.

LICAPHROPS Ameghino.

Licaphrops Amegh.; An. del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 448.

I have seen no example of this genus, which is characterized by the great development of the antero-internal cusp (protocone) of the upper molars and the great reduction of the postero-internal cusp (hypocone), giving the crown a somewhat triangular shape.

LICAPHROPS COALESCENS Ameghino.

Licaphrops coalescens Ameghino; Loc. cit., p. 455.

This, the only known species from the Santa Cruz beds, is represented by a single upper molar, which measures 15 mm. in antero-posterior by 13 mm. in transverse diameter.

PROTEROTHERIUM Ameghino.

(Plates VII, Figs. 8-11; VIII-X; XI, Figs. 1-11; XII, Figs. 1, 2; XIII, Fig. 8.)

Proterotherium Amegh.; Bol. de la Acad. Nac. de Cienc. de Córdoba, T. V, 1883, p. 291.

Anoplotherium Bravard (*non* Cuvier); Monogr. de los terren. eoc., etc., 1858.

Anchitherium Burmeister (*non* v. Meyer); Descr. phys. de la Répub. Argent., T. III, 1879, p. 479.

Anisolophus Burm.; Anales del Mus. Nac. de Buenos Aires, T. III, 1885, p. 172.

Diadiaphorus Mercerat, in part; Rev. del Mus. de La Plata, T. I, 1891, p. 458.

Oreomeryx Mercerat, in part; Ibid., p. 465.

Anomodonttherium Mercerat; Ibid., p. 461.

Thoatherium Mercerat (*non* Amegh.); Ibid., p. 455.

Diaphragmodon Mercerat; Ibid., T. III, 1893.

Diadiaphorus Lydekker, in part; Anales del Mus. de La Plata, T. III, 1893.

Tichodon Amegh.; Énum. Synopt. de Mamm. Foss. de Patagonie, 1894, p. 43.

Heptaconus Amegh.; Ibid., p. 44.

Though closely allied to *Diadiaphorus*, this genus comprises smaller and more slenderly built animals and differs in many details of dental and skeletal structure from that genus. As the more salient characteristics may be noted the following features. (1) In most of the species the second upper premolar has the inner ridge divided into cusps, while p^3 and p^4 have a small, though distinct postero-internal cusp (tetartocone). (2) The upper molars have the internal cusps well separated, but in m^3 the hypocone is usually absent or indistinguishably fused with the posterior cingulum. (3) The last lower molar has a small talon and a very small postero-internal pillar, which is still smaller in m_2 and m_1 . (4) The nasal bones are much longer than in *Diadiaphorus*. (5) The limbs and feet are much more slender and elongate than in the latter.

Dentition (Pls. VII, figs. 10, 11; VIII, figs. 2-8; IX, figs. 1-10; X, figs. 1-5, 7-15).

A. Upper Jaw. The single incisor is a caniniform tusk, resembling that of *Diadiaphorus* and *Licaphrium* in form, but varying considerably in size in the different species and almost certainly also in the two sexes. A long diastema separates the incisor from the first premolar, which is small and two-rooted, with compressed conical crown, and internal ridge even less developed than in *Diadiaphorus*. The second premolar has

three roots; the crown has a single external, cordiform lobe and an internal ridge, which in most of the species is distinctly though imperfectly divided into anterior and posterior cusps (deutero- and tetartocone), while in *Licaphrium* this ridge is not so divided. The third and fourth premolars are nearly molariform and of a pattern which closely resembles those of *Diadiaphorus*, but the two inner cusps are even less distinctly separated. In certain individuals the posterior conule is absent in p^3 , while in others it is well defined; in p^4 this conule is of variable size, sometimes differing notably on the two sides of the same individual. The difference of these premolars from those of *Licaphrium* is quite decided and represents a more advanced stage of development.

The upper molars also are very like those of *Diadiaphorus*, but with internal cingulum less prominent, or absent, while externally the cingulum is better defined and is continued down upon the anterior border, making a more distinct anterior style. The inner cusps are well separated, almost as deeply as in the last named genus. The third molar is the smallest of the series and its posterior half is much reduced, having no distinct postero-internal cusp, merely a prominent posterior cingulum. Between the inner cusps of one or more of the molars sometimes appears a pointed cingular tubercle, which is absent in most species, in others minute and variable, while in only one species (*P. acre*) does it become at all conspicuous. Ameghino has referred this species to a distinct genus, *Heptaconus*, but I think this is attributing too much importance to such a character. The molars are not so broad and heavy as in *Licaphrium* and the internal cusps are more separate.

B. Lower Jaw. The median incisor, presumably i_2 , has a small, chisel-shaped, antero-posteriorly compressed crown, with transverse cutting edge; the lateral incisor, probably i_3 , is very much larger and caniniform and is broad antero-posteriorly, very thin transversely, which is its principal difference from the corresponding tooth of *Diadiaphorus*. The tusk is less procumbent than in *Licaphrium*. The canine follows the lateral incisor after a very short diastema and is separated from p_1 by a somewhat longer one; it is very small and has a compressed, bluntly conical crown.

The first premolar is relatively a little smaller than in *Licaphrium* and resembles that of *Diadiaphorus*, but is more compressed laterally; p_2 is also much as in the latter, but is somewhat higher and more pointed and

has the antero-internal ridge rather better defined. The third premolar is nearly molariform, with the difference that near the inner end of the anterior crescent is a well defined vertical ridge, which is more prominent than in *Diadiaphorus* and differs from that of *Licaphrium* in being a ridge instead of a pillar. A remnant of the same structure appears in p_4 , but the ridge is much smaller and is separated from the antero-internal border only by a narrow groove. In perfectly unworn examples of p_3 a minute internal cusp may be present at the hinder end of the posterior crescent, a feature which is quite constant and better developed in *Licaphrium*. The fourth premolar is more completely molariform and, as already mentioned, the antero-internal ridge is reduced to a mere vestige. The cingulum varies in development on the premolars, but is never very prominent.

The molars are composed of two crescents, with the valleys opening inwardly: on the inner side of the posterior end of the second crescent is a small pillar, which is smallest in m_1 and largest in m_3 ; in m_1 this pillar is visible only in unworn teeth, as it is rapidly removed by abrasion: m_3 has in addition a small, but well defined talon. On the molars the development of the cingulum varies much, even on the opposite sides of the same jaw. Compared with those of *Licaphrium*, the lower molars of *Proterotherium* differ in being narrower and less massive, and in having better defined valleys and much smaller postero-internal pillar.

Milk Dentition. — I have seen no examples of the anterior upper temporary teeth and only much worn specimens of the deciduous premolars. Doubtless, however, the relationships are essentially the same as in *Thoatherium*, which is described in a subsequent section. Both dp^3 and 4 , of which the latter is much the larger, appear to be molariform in pattern. All the mandibular milk-teeth are well displayed in the collection (Pl. X, figs. 15, 15a) and all of the antemolars have predecessors in the milk-series, but there are some interesting differences of form between the temporary teeth and their permanent successors. The median incisor (di_2) is larger, more procumbent, more pointed and less chisel-shaped than i_2 , while the lateral, di_3 , is very much smaller than i_3 and hardly larger than the median, so that the milk-incisors of *Proterotherium* might easily be mistaken for the permanent ones of *Thoatherium*. The temporary canine differs from the permanent one merely in being somewhat larger. The first milk-premolar is far larger than p_1 and is implanted by two well separated roots; dp_2 resembles p_2 in form, but is longer and thicker and the ridges

and valleys of the inner side are better developed. The third milk-premolar is the largest tooth of the temporary series, which is chiefly due to the enlargement of the anterior crescent; the antero-internal ridge is smaller than in p_3 , but the postero-internal pillar is much more distinct. The fourth temporary premolar is like p_4 , except in being somewhat larger and more completely molariform, as the antero-internal cusp is absent and the posterior pillar larger.

Skull (Pls. VIII, figs. 1, 1a, 4; IX, figs. 11, 11a). — The skull is very like that of *Diadiaphorus* and *Licaphrium*, but has a lighter and more graceful appearance, and there are many differences of detail. The cranium is somewhat longer than in *Diadiaphorus* and the face correspondingly shorter, but narrows forward more gradually. The orbit is slightly lower in position and presents rather more directly outward. The occiput is relatively broader and the foramen magnum lower and wider, while the fossa between the exoccipital and the squamosal is narrower, so that the periotic is nearly, and in some cases quite, excluded from the surface of the skull.

The parietal zone is somewhat longer and forms a slightly less full and capacious brain-case, but extends a little farther down upon the side of the cranium, narrowing the squamosals in a corresponding degree. The zygomatic process is relatively broader dorso-ventrally and has a more arched and elevated dorsal border, making a deeper groove between the process and the side of the cranium; the glenoid cavity is similar in form, but has a deeper posterior concavity, and the postglenoid process is narrower and less massive. Anteriorly, the zygomatic process extends farther into the more deeply notched jugal. The orbit is closed behind, as in *Diadiaphorus*, but the posterior boundary, made up of the united frontal and jugal processes, is more slender and less twisted: the lachrymal foramen is larger and more conspicuous and has a more posterior position, being placed on the rim of the orbit. The frontals are somewhat more convex, which is probably due to a larger development of the sinuses.

The most marked difference from the skull of *Diadiaphorus* is to be found in the nasals and premaxillaries. The nasals are much longer and narrower and taper more gradually to the anterior point; each is convex transversely, so that there is a well marked depression along the median line of suture between them: they have quite extensive sutures with the premaxillaries, while in *Diadiaphorus* there is no such contact.

In *Proterotherium* the premaxillæ differ from those of *Diadiaphorus* in the much smaller part which is broad and thick, with rounded and depressed dorsal surface, and in the far broader ascending ramus, which has a thinner and much more nearly vertical anterior border; the incisive foramina are relatively larger, but are entirely confined to the premaxillæ. Owing to the differences of form of the nasals and premaxillaries, the anterior nares have quite a different shape in the two genera. The maxillaries are very similar in both, but in *Proterotherium* the infraorbital foramen is proportionally much larger, though still very small, single and placed nearer to the orbit. The palatines are very long, extending forward to m^1 or p^4 , and the hard palate is narrow and concave, while the posterior nares are not produced so far forward as in *Diadiaphorus*.

The mandible differs but little from that of the last named genus; the symphysis is broader and more depressed, less concave on the dorsal side and more procumbent, the ventral border rising very gradually to the incisive alveolus. The coronoid, which is high and narrow, has a greater inclination forward, especially in young animals, and the condyle is narrower antero-posteriorly, more convex transversely.

Skeleton.—Except for smaller size and more slender proportions, all the bones of the skeleton closely resemble those of *Diadiaphorus*. Very few vertebræ have as yet been found in association with any of the specimens. The atlas has a low, but distinct neural spine, and a well defined hypapophysis, which projects backward from the hinder border of the inferior arch: the atlanteo-diapophysial notch is in process of conversion into a foramen, as is indicated by a short, pointed process arising from the anterior border of the notch; the depression for the odontoid process of the axis is narrow and deeply concave.

The lumbar vertebræ, so far as they are known, resemble those of *Diadiaphorus* in structure, though the metapophyses are relatively more prominent. On the last lumbar the transverse processes are extremely broad and articulate with those of the first sacral by deep concavities, as appears to be the case in all of the Litopterna. The number of sacral vertebræ is not definitely known, but probably exceeded six. The first vertebra (Pl. XII, fig. 2) is very broad, but behind this the sacrum rapidly contracts, becoming very narrow and very shallow dorso-ventrally, which indicates that the tail was short: the coalesced neural spines form a low ridge, with a somewhat higher ridge on each side of it, apparently due to the fused metapophyses.

The scapula (Pl. XI, fig. 1) is short and quite broad and the spine is so placed that the prescapular fossa is considerably larger than the postscapular, and the whole blade is relatively shorter, broader and more rounded than in *Diadiaphorus*. The neck is broad and there is no distinct coraco-scapular notch; the glenoid cavity is of a somewhat peculiar shape, contracting to a point anteriorly; the coracoid is not known, but appears to have been small. The coracoid border curves forward strongly in ascending from the neck to the widest part of the blade, which is about the middle of the proximo-distal height, thence curving backward and upward to the suprascapular border: the glenoid border is straight. The spine rises steeply and is somewhat recurved, with convex anterior face, ending distally in a short acromion: the single metacromion is a prominent triangular process, placed just above the acromion, and appears to have been distinctly larger and more prominent than in *Diadiaphorus*. This scapula differs very strikingly from that of *Theosodon* (q. v.).

The humerus (Pl. XI, fig. 2) is almost exactly like that of *Diadiaphorus* on a smaller scale: it is short and rather slender, the deltoid ridge is obscurely marked and the distal trochlea is of a simple, pulley-like shape.

Although the ulna and radius are not fused at any point, they are in contact with each other for nearly their entire length, so that there is hardly any radio-cubital arcade. The radius (Pl. XI, figs. 2, 10) is short, somewhat shorter than the humerus; the shaft is slender, of oval cross-section, but somewhat irregular in shape. The ulna (Pl. XI, fig. 3) is hardly reduced at all and is nearly as thick as the radius; its distal end is compressed and plate-like and, in addition to the surfaces for the pyramidal and pisiform, has a small, though distinct facet for the lunar.

The carpus (Pl. XI, figs. 9, 9a) closely resembles that of *Diadiaphorus* in the shape and mutual connections of its various elements, but there are many minor differences. The scaphoid is higher proximo-distally in proportion to its width; the dorsal convexity of the radial facet is more sharply defined and the trapezoid facet incises the bone more deeply; the facet for the trapezium is relatively very large. The lunar is proportionately higher and narrower; its proximal surface is similarly oblique, descending steeply toward the radial side, and the facet for the ulna, though very small, is much more distinct, while the knob-like protuberance from the palmar face is smaller. Except for its smaller size, the pyramidal is almost exactly as in *Diadiaphorus*, but the facet for the ulna

is rather more convex and that for the pisiform makes a more open angle with it. The trapezium is an irregular, nodular bone; it articulates proximally with the scaphoid by a large, slightly convex surface, laterally with the trapezoid and has an extensive oblique facet for the second metacarpal; the distal end is not bluntly pointed and rugose, as it is in *Theosodon* and the Perissodactyla, but transversely truncated and smooth, as though for the attachment of a vestigial first metacarpal, such as Ameghino has described in *Diadiaphorus* ('94*b*, p. 268). The trapezoid resembles that of the latter genus, except in being relatively narrower, as is also the magnum, of which the width but slightly exceeds the proximo-distal height, and the facet for the lunar is slightly more raised and convex in the dorso-palmar direction, while that for the scaphoid is more concave transversely. I have seen no example of the unciform.

The metacarpus (Pl. XI, figs. 4, 9, 9*a*), like the other bones of the extremities, much resembles that of *Diadiaphorus*, but is rather more slender. Metacarpal II is longer in proportion to III than in the last named genus, but is of similar shape and has similar connections with the carpus. Metacarpal III is somewhat more slender than in *Diadiaphorus*, (though the difference is not so great as it appears at first sight, because of the smaller size of *Proterotherium*) and broadens less to the distal end: the tuberosity near the proximal end for the attachment of the extensor tendon is less prominent and the distal carina is rather sharper. Metacarpal IV, like II, is relatively longer than in *Diadiaphorus*, but otherwise similar. I have seen no example of the vestigial mc. V, but its presence is demonstrated by a minute facet on the head of mc. IV.

The phalanges of the median digit (Pl. XI, figs. 9, 9*a*) are very like those of *Diadiaphorus* and the proximal phalanx has almost the same proportions as in that genus; the second is of more uniform width, contracting less toward the distal end, while the ungual is a little more depressed, with less convex dorsal surface. Obviously, there is some mistake in Ameghino's figure of *P. intermixtum* [sic] ('94*b*, p. 269, fig. 10) which is apparently due to the association of phalanges of *Thoatherium* with the metacarpals of *Proterotherium*.

The pelvis (Pl. XII, fig. 2) has considerable resemblance to that of the equine genus *Mesohippus* from the Oligocene of North America. The ilium is short and has a short peduncle, which rapidly expands into the very broad anterior plate; this plate is obscurely divided by a shallow

emargination of the crista into a shorter and narrower internal portion, which curves dorsally above the sacrum, and a very long and pointed external portion; the acetabulum is large and prominently projecting. The ischium is short and laterally compressed, but quite stout. The pubis is short and depressed and the obturator foramen is large and of longitudinally oval shape.

The femur (Pl. XI, fig. 5) has a more equine appearance than any other long bone of the skeleton, though it differs from that of *Diadiaphorus* merely in being more slender, in the narrower and deeper rotular groove and in the more prominent backward projection of the condyles.

The patella (Pl. XI, figs. 6, 6a) is a short and broad, shield-shaped bone, which narrows distally to a bluntly rounded point. It differs from that of *Diadiaphorus* in being much less massive and thick antero-posteriorly.

The tibia (Pl. XI, fig. 7) is heavy and considerably shorter than the femur: the spine is low and bifid, with its two parts quite widely separated; the cnemial crest is prominent, but short, speedily dying away upon the shaft, and the sulcus for the tendon of the extensor longus digitorum is very deep and conspicuous. The distal moiety of the shaft is of more trihedral, less oval, section than in *Diadiaphorus* and the astragalar facets are deeper, while the anterior intercondylar tongue is more prominent.

The fibula (Pl. XI, fig. 7) has a much reduced and irregular shaft, with ends which are laterally compressed, but expanded antero-posteriorly. The two leg-bones are in contact only at the proximal and distal ends, but the space between them is very narrow throughout.

Like all other parts of the skeleton, the pes (Pls. XI, fig. 4; XII, fig. 1) closely resembles that of *Diadiaphorus*, with many differences of detail. The astragalus has a trochlea which is slightly narrower in proportion to the length of the bone, and somewhat more deeply and sharply grooved: the neck is relatively longer and is less obliquely directed toward the tibial side: on the plantar surface the facet for the sustentaculum of the calcaneum is not continued so far proximally and narrows less in the same direction, being of almost uniform width, except near the distal end, where it suddenly widens, making the external border of the facet much more concave than in *Diadiaphorus*; this facet is separated from the ectal calcaneal facet by a narrower and shallower sulcus than in the latter.

The proportions of the calcaneum are quite as in *Diadiaphorus*; the sustentaculum arises nearer to the plantar border, is not so heavy and has

a more rounded, less angular outline: the facet for the astragalus is narrower and somewhat less concave and is bounded externally by a larger and deeper sulcus, while the cuboid facet is somewhat less oblique and concave. The articular surface for the fibula is small and irregular in shape. The navicular resembles that of *Diadiaphorus*, except that the proximal surface contracts less on the plantar side. The entocuneiform is very large, but compressed and scale-like, attached to the navicular laterally rather than proximally and articulating extensively with the second metatarsal. The mesocuneiform is very small in all three dimensions, being much more reduced, especially in proximo-distal length, than in *Diadiaphorus*. The large and heavy ectocuneiform has nearly the same proportions as in the latter, except that the facet for mt. III narrows less abruptly toward the plantar side.

The metatarsus shows some noteworthy differences, though of a very minor character, from that of *Diadiaphorus*. Owing to the reduction of the mesocuneiform, the second metatarsal rises higher above the head of mt. III than in the latter and has a much more extensive lateral contact with the ectocuneiform and also extends farther distally, so that, as a whole, it is considerably longer than in the genus last named. Metatarsal III is somewhat longer and considerably stouter than metacarpal III, thus reversing the relative lengths which occasionally are found in *Diadiaphorus* and the difference in breadth is also greater than in that genus. I have seen no complete specimens of mt. IV, the proximal end being absent; distally it extends to the same level as mt. II.

The proximal phalanx of the median digit is of the same length as that in the manus, or, it may be a little shorter, somewhat thicker and less depressed planto-dorsally. The second phalanx is likewise thicker and a little longer than in the manus. Of the ungual I have seen no example.

Species. — Of all the Santa Cruz genera of this family, *Proterotherium* is the most varied and abundant, and was evidently in a state of vigorous development. This renders the discrimination of species exceedingly difficult, and for no other genus of the Litopterna does the absence of any minutely exact stratigraphical knowledge of the Santa Cruz beds have a more unfortunate effect in confusing the taxonomy. Most of the species are very variable and it is rare to find two individuals that seem to be specifically identical. There is no ground for surprise, therefore, to find that among the casts of the Ameghino collection there is frequently as

great a difference between two specimens referred to the same species as between two nominal species. Unless one is prepared to form a different species for almost every individual, it is impossible to do more than to make a tentative and more or less arbitrary arrangement.

It cannot be supposed that eighteen or twenty species of a single mammalian genus should have co-existed at the same time and place; the difficulty lies in determining how many of these forms were actually contemporaneous, or, in other words, to distinguish between variants and mutants. Probably, the number of species to be recognized will be materially reduced as the result of future investigations, for several of those already proposed have been founded upon insufficient material and almost all upon variations of the teeth only.

It is significant of the rapid modification which *Proterotherium* was undergoing in Santa Cruz times, that the variations appear to be largely hap-hazard and that the species, or varieties, do not obviously fall into groups, or subgenera, each group distinguished by some relatively important characteristic. With great constancy in general plan, almost every element of the tooth-pattern is subject to many minor variations, and these variations do not occur together in a definite manner, but in all sorts of combinations. It is as though some substantial improvement were being sought by the method of "trial and error."

In a recent paper on the black bear of Labrador, Dr. J. A. Allen has described a somewhat similar case among existing mammals. "Individual variation is especially manifest in the size and form of M^2 , which varies greatly in skulls otherwise similar in general size and form. This tooth varies in length, in specimens that seem unquestionably of the same sex, from 22 to 27 mm., or about 20 per cent. of the mean. While these variations are evident from the table of measurements, they are far more impressive when the actual teeth are compared, since the shape of the tooth varies as much as the size, especially in the development of the 'keel' portion. This is usually about one-third the length of the tooth, but may be only one-fourth as long. The relation of width to length is also markedly variable" (Allen, '10, pp. 3-5).

PROTEROTHERIUM AUSTRALE (Burmeister).

(Plates IX, Figs. 7, 8; X, Figs. 2, 3, 14.)

Anchitherium australe Burmeister; Descr. phys. de la Répub. Argent., T. III, 1879, p. 479.

Anisolophus australis Burmeister; Anales del Mus. Nac. de Buenos Aires, T. III, 1885, p. 172.

Proterotherium australe Amegh.; Enum. sistem., etc., 1887, p. 19.

Diadiaphorus australis Mercerat; Rev. del Mus. de La Plata, T. I, 1891, p. 459.

Anisolophus Burmeisteri Mercerat; Ibid., p. 464 (fide Ameghino).

Proterotherium cingulatum Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 296.

Proterotherium angulatum Amegh.; Ibid., p. 345 (typographical error).

Proterotherium curticens Amegh.; Ibid., p. 296.

Proterotherium mixtum Amegh.; Énum. Synopt., etc., 1894, p. 39.

This species is apparently not represented in the Princeton or New York collections save by one imperfect skull in the former (No. 15,368), and the present account is chiefly derived from the descriptions and figures of Burmeister and Ameghino and from the casts sent me by the latter. The type specimen is a fragment of the upper jaw, with six of the grinding teeth (p^2 — m^3) in place, but these teeth are broken and lack the outer wall; they show, however, the essential features of the pattern. I am inclined to refer to the present species such representatives of the genus as are of moderately large size and have the postero-internal cusp (tetartocone) well developed in p^3 and 4 , while in m^3 the postero-external cusp is considerably narrower than the antero-external and the postero-internal (hypocone) is wanting. The presence or absence of a cingulum, which Ameghino employs in the discrimination of species, is a very untrustworthy criterion and, I believe, is quite without value in this group.

The definition of *P. australe* given above is necessarily quite elastic and permits the inclusion in the species of a considerable range of variation both in size and in the minor details of the molar-pattern, but no greater in either respect than Allen has shown to exist in the recent *Ursus americanus* (loc. cit.).

In the following table of measurements No. 6 is a cast of the type specimen of *P. mixtum*, No. 21 of *P. curticens*, and No. 5 of the co-type of

P. cingulatum. In all of these cases the reference to *P. australe* is more or less uncertain, but the available evidence is, in my judgment, insufficient for any separation.

MEASUREMENTS.

	No. 6.	No. 21.	No. 5.	No. 15,368.
Upper dentition, length i^2-m^2	.109			.111
“ premolar-molar series, length	.080	.072		.081
“ premolar series, length	.044	.038		.044
P ¹ , length (<i>i. e.</i> , antero-posterior diameter)	.010	.0085		.0095
“ width (<i>i. e.</i> , greatest transverse diameter)	.009	.008		.0075
P ² , length	.0105	.009		.010
“ width	.012	.011		.0115
P ³ , length	.0105	.0095		.0115
“ width	.0145	.012		.014
P ⁴ , length	.013	.011		.012
“ width	.0165	.014		.0165
Upper molar series, length	.038	.034		.038
M ¹ , length	.013	.010		.012
“ width	.018	.017		.017
M ² , length	.014	.012		.0135
“ width	.020	.017		.0185
M ³ , length	.0125	.0105		.0125
“ width	.018	.0165		.018
Lower dentition, length i_3-m_3	.102		.104	
“ premolar-molar series, length	.083		.086	
“ premolar series, length	.044		.044	
P ₁ , length	.008		.0085	
“ width	.004		.004	
P ₂ , length	.010		.011	
“ width	.006		.007	
P ₃ , length	.012		.013	
“ width	.008		.0095	
P ₄ , length	.013	.013	.012	
“ width	.010	.0103	.011	
Lower molar series, length	.041	.040	.042	
M ₁ , length	.012	.0115	.012	
“ width	.010	.010	.0105	
M ₂ , length	.013	.013	.013	
“ width	.011	.010	.011	
M ₃ , length	.015	.0145	.016	
“ width	.011	.0095	.010	

N. B. The discrepancies in the totals are due to overlapping of the teeth.

It will be observed that there is a remarkable difference of size between

the upper and lower teeth of *P. curticens* and, though both casts are marked "type," there is probably some mistake involved, for the two cannot be of the same individual, and in the original description of the species only the mandibular dentition is mentioned ('91, 296).

Localities.—The type of *P. australe* was found on the banks of the Rio Chico, for the other supposed species localities have not been given. No. 15,368 was collected by Mr. Hatcher at Killik Aike.

PROTEROTHERIUM PRINCIPALE Ameghino.

(Plates X, Figs. 4, 5, 8, 11; XII, Figs. 1, 1a.)

Diadiaphorus velox Lydekker (*non* Amegh.); *Anales del Mus. de La Plata*, T. II, 1893, p. 60.

Proterotherium principale Amegh.; *Enum. Synopt.*, etc., 1894, p. 37.

Proterotherium divortium Amegh.; *Ibid.*, p. 38.

Proterotherium dichotomum Amegh.; *Anales del Mus. Nac. de Buenos Aires*, Ser. 3, T. III, p. 152.

Though nearly allied to *P. australe*, this appears to be a distinct species, being not only larger than the latter, but also having certain peculiarities of tooth pattern which appear to be of specific importance. P^3 has no posterior conule and the postero-internal cusp (tetartocone) is very small and imperfectly separated from the antero-internal (deuterocone), while in p^4 this element is somewhat larger and more distinct, though decidedly less so than in *P. australe*. The third upper molar has no hypocone, or a very minute one, and the posterior ridge, formed by the cingulum, is unusually low; the protocone is very large, of pyramidal shape, and extends across nearly the entire internal face of the crown.

In the mandible, the diastemata between the lateral incisor and the canine and between the latter and the first premolar are very short.

P. divortium (Pl. X, figs. 4, 5), which was established upon portions of the upper and lower jaws, appears to be only an individual of the present species with slightly more slender mandible than is common. Of *P. dichotomum* (Pl. X, fig. 8), the type is an isolated upper molar (m^2) which agrees quite closely in size and pattern with the corresponding tooth of *P. principale*.

In the subjoined table of measurements, No. 16 is a cast of the type; No. 14 is a cast of a second and considerably older individual, an incom-

plete mandible associated with an isolated m^2 ; No. 13 (Pl. X, fig. 11), a cast of a fragment of the mandible, also marked "type," but evidently belonging to a much older animal. No. 17 is a cast of the type of *P. divortium* and No. 27 a cast of the type of *P. dichotomum*. No. 15,436 is a young animal with m^2 and $\frac{3}{3}$ not yet fully protruded.

MEASUREMENTS.

	No. 16.	No. 17.	No. 14.	No. 13.	No. 27.	No. 15,732.	No. 15,436.
Upper dentition, length $i^2 - m^2$.	.117						
Upper premolar- molar series, length .	.087						
Upper premolar series, length .	.0465						
P ¹ , length (<i>i. e.</i> , ant.- post. diam.) .	.0095						
P ¹ , width (<i>i. e.</i> , greatest transv. diam.) .	.0095						
P ² , length .	.010						
" width .	.012						
P ³ , length .	.013						
" width .	.016						
P ⁴ , length .	.0135	.013					
" width .	.018	.018					
Upper molar, series, length .	.042	.041					
M ¹ , length .	.015	.013					
" width .	.0185	.018					
M ² , length .	.017	.015			.0155		
" width .	.021	.0195			.020		
M ³ , length .	.014	.0135	.014				
" width .	.020	.0195	.020				
Lower dentition, length $i^3 - m^3$.						.112	
Lower premolar- molar series, length .						.089	
Lower premolar series, length .						.046	
P _I , length .		.009				.0085	
" width .		.004				.004	

	No. 16.	No. 17.	No. 14.	No. 13.	No. 27.	No. 15,732.	No. 15,436.
P ₂ , length . . .		.012	.012	.011		.011	
" width . . .		.006	.0065	.006		.005	
P ₃ , length . . .		.014	.0135	.014		.0135	.0135
" width . . .		.009	.0105	.0105		.009	.009
P ₄ , length . . .			.014	.013		.013	.014
" width . . .			.0125	.012		.011	.011
Lower molar series,							
length . . .			.045			.043	.044
M ₁ , length . . .			.013			.0125	.013
" width . . .			.012			.011	.011
M ₂ , length . . .			.0145			.015	.014
" width . . .			.012			.012	
M ₃ , length . . .			.017			.016	.017
" width . . .			.011			.011	
Mandible, depth							
below p ₃ . . .		.0215	.023			.0215	.023

Associated with the mandible, No. 15,436, is the somewhat incomplete hind-foot shown in Pl. XII, fig. 1. It is remarkable for the relative shortness and heaviness of most of its elements and, had it been found alone, would probably have been regarded as belonging to some species of *Licaphrium*. With this specimen may be compared another, No. 15,712, which, unfortunately, was not found in association with teeth, and therefore cannot be definitely referred to any species. The radius of this second individual, shown in Pl. XII, fig. 10, agrees in the dimensions of the distal end with those of *P. cavum* (see p. 76) but the hind-foot is apparently too large for reference to that species.

MEASUREMENTS.

	No. 15,436.	No. 15,712.
Calcaneum, length	.0645	.069
" width over sustentaculum	.024	.023
" " at end of tuber	.016	.015
" " " middle of tuber	.009	.008
Astragalus, length	.032	
" width of trochlea	.017	
" " " distal end	.0165	
Tarsus, length in median line	.042	
" width	.028	
Ectocuneiform, length	.008	
" width	.016	

	No. 15,436.	No. 15,712.
Metatarsal II, length	.061	.059
“ “ proximal width	.004	.004
“ “ “ thickness	.010	.0095
“ “ distal width	.006	.006
“ “ “ thickness	.0105	.0105
Metatarsal III, length	.075	
“ “ proximal width	.019	
“ “ “ thickness over hook	.021	
“ “ distal width	.020	
Phalanx 1, digit III, length	.037	.037
“ 1, “ “ proximal width	.020	.020
“ 1, “ “ “ thickness	.012	.012
Phalanx 2, digit III, length		.021
“ 2, “ “ proximal width		.0165

Localities.—Ameghino gives no localities for *P. principale* or *P. divor-
tium*; the type of *P. dichotomum* was found at Mt. Observation. No.
15,732 was collected by Mr. Hatcher at Halliday's Ranch and No. 15,436
at Killik Aike.

PROTEROTHERIUM PYRAMIDATUM Ameghino.

(Plate VIII, Fig. 5.)

Proterotherium pyramidatum Amegh.; Énum. Synopt., etc., 1894, p. 37.

As in the species of *Licaphrium* of the same name, the antero-internal cusp (protocone) of m^2 is relatively large, flattened on the inner face and of quite pyramidal shape; there is no hypocone and the posterior cingulum turns sharply forward at the inner angle, becoming continuous with the sharp edge of the protocone.

Among the casts sent to me by Dr. Ameghino are two specimens referred to the present species. One of these (No. 9), the type, is a fragment of the right maxillary with all three molars in place, and the other (No. 10) has all of the grinding teeth of both upper and lower jaws, except m_3 . Although both individuals conform to the definition of the species as given above, there are some instructive differences between them in the character of m^3 . In the type, that tooth is much reduced in size, the antero-external border not overlapping the hinder margin of m^2 ; the two external lobes are of nearly the same size and the posterior conule is placed very near to the posterior cingulum. In No. 10, on the other hand, m^3 is relatively larger and the anterior margin overlaps the hinder

border of m^2 ; the two outer lobes are of less equal size, owing to the narrowness of the posterior cusp, and the posterior conule is more removed from the cingulum than is the case in the type. This second individual shows that the upper premolars are of the *P. australe* type, p^3 and 4 having nearly square crowns, with well developed tetartocone, while p_1 is very small and single-rooted.

MEASUREMENTS.

	Type.	No. 10.
Upper premolar-molar series, length		.081
“ premolar series, length		.044
P^1 , length (<i>i. e.</i> , antero-posterior diameter).		.009
“ width (<i>i. e.</i> , greatest transverse diameter)		.009
P^2 , length		.0105
“ width		.012
P^3 , length		.012
“ width		.015
P^4 , length		.0125
“ width		.017
Upper molar series, length	.037	.038
M^1 , length	.013	.013
“ width	.018	.0175
M^2 , length	.0135	.014
“ width	.018	.0175
M^3 , length	.010	.012
“ width	.0165	.018
Lower premolar series, length		.039
P_1 , length		.0055
“ width		.0035
P_2 , length		.010
“ width		.0065
P_3 , length		.012
“ width		.009
P_4 , length		.0125
“ width		.011
M_1 , length		.0115
“ width		.011
M_2 , length		.013
“ width		.011

Localities.—Not given.

PROTEROTHERIUM BROWNII sp. nov.

(Plate IX, Figs. 2, 2a.)

The type and only known representative of this species is a specimen belonging to the American Museum of Natural History (No. 9568) and containing the upper dentition almost complete and unworn. The species closely approximates *P. australe* in size and the grinding teeth most resemble those of the latter. The second upper premolar has two small and conical internal cusps, which are almost median in position, and a large posterior heel, defined by the elevated cingulum. This pattern is different from that of the corresponding tooth in any other species which I have observed, and, if constant, is doubtless a valuable diagnostic character. In p^3 and 4 the tetartocone is well developed and in the upper molars the posterior conule is almost exactly midway between the two internal cusps. M^3 is remarkable for the extreme reduction of the postero-external cusp, a reduction greater than in any other known example of the genus.

MEASUREMENTS.

Upper dentition, length i^2 — m^3		.106	P^3 , width		.015
I^2 , antero-posterior diameter		.007	P^4 , length		.0125
" transverse	"	.0075	" width		.016
Upper premolar-molar series, length		.076	Upper molar series, length		.0365
" premolar series, length		.042	M^1 , length		.013
P^1 , length (<i>i. e.</i> , ant.-post. diam.)		.008	" width		.017
" width (<i>i. e.</i> , transverse diam.)		.007	M^2 , length		.014
P^2 , length		.0105	" width		.018
" width		.0115	M^3 , length		.010
P^3 , length		.012	" width		.018

Locality.—The type was collected by Mr. Barnum Brown at Monte Leon.

This species is named in honor of Mr. Brown, who discovered and collected it.

PROTEROTHERIUM BRACHYGNATHUS Ameghino.

(Plate X, Figs. 12, 13.)

Proterotherium brachygnathum Amegh.; Énum. Synopt., etc., 1894, p. 38.

Licaphrium proclivum Amegh.; Ibid., p. 42.

The type of this species is a fragment of the symphyseal region of the mandible, with only one tooth, p_1 of the left side, intact. The lower tusk

is slender and procumbent, doubtless an indication that the animal was a female. All of the teeth, from i_3 backward, are closely crowded together and without diastemata, which is the diagnostic feature of the species. The single complete tooth, p_4 , measures 12.5 mm. in antero-posterior, by 9.5 mm. in transverse diameter, and the depth of the mandible below p_4 is 19.5 mm.

The type of *Licaphrium proclivum* is the right horizontal ramus of a mandible with all of the teeth, except the median incisor and the canine, in place, and appears to have been a slightly smaller animal than the preceding individual. The lower tusk (i_3) is much larger and more erect than in the latter, but this is probably merely a sexual difference. The alveolus of the missing canine is almost in contact with those of i_3 and p_1 , and the latter, which is small, extensively overlaps the anterior border of p_2 .

In the table, the measurements are taken from a cast of the type of *L. proclivum*.

MEASUREMENTS.

Lower dentition, length i_3 - m_3	.092	P_3 , width	.008
I_3 , antero-posterior diameter	.008	P_4 , length	.0115
" transverse "	.005	" width	.010
Lower premolar-molar series, length	.077	Lower molar series, length	.038
" premolar series, length	.039	M_1 , length	.011
P_1 , length (<i>i. e.</i> , ant.-post. diam.)	.0075	" width	.010
" width (<i>z. e.</i> , greatest trans. diam.)	.003	M_2 , length	.0125
P_2 , length	.0105	" width	.010
" width	.005	M_3 , length	.0135
P_3 , length	.012	" width	.0095

Localities. — Not given.

PROTEROTHERIUM INTERMEDIUM Ameghino.

(Plates VIII, Figs. 4, 4a; X, Figs. 7, 9, 10.)

Proterotherium intermedium Amegh.; Énum. Synopt., etc., 1894, p. 38.

The type of this species (Pl. X, fig. 7), is the right horizontal ramus mandibuli of an old individual, with the anterior teeth badly broken. A specimen in the collection of the American Museum (No. 9267, Pl. X, figs. 9, 10) consisting of the facial region of a skull and associated lower jaw, and a young mandible in the Princeton collection (No. 15,996, Pl. VIII, figs. 4, 4a), appear to be referable to the same species. The posterior upper premolars, p^3 and 4 , are intermediate in type between those of *P. australe*

and those of *P. cavum*, the postero-internal cusp, or tetartocone, being smaller than in the former species, larger than in the latter. In m^1 the progress of abrasion has united the posterior conule with the hypocone, as in *P. australe*, and in both m^1 and m^2 between the two internal cusps is a minute pillar, which is present, though apparently not constant, in many of the species, but attains importance only in *P. acre* (q. v.). M^3 agrees closely in size with that of *P. perpolitum* and also in the very unusual feature that the two external lobes of this tooth are of nearly equal width. It differs, however, from the latter species in the development of the hypocone, which is larger than in any other species which I have observed, but is wanting in *P. perpolitum*. In the mandible, the canine is separated by unusually short diastemata from the tusk and p_T . The latter is very small and has a single cylindrical root.

In the succeeding table, No. 20 is a cast of the type-specimen; No. 9267 is in the collection of the American Museum and No. 15,996 in that of Princeton University.

MEASUREMENTS.

	No. 9267.	No. 20.	No. 15,996.
Upper dentition, length $i^2 - m^3$	.094		
I^2 , antero-posterior diameter	.007		
“ transverse diameter	.006		
Upper premolar-molar series, length	.070		
“ premolar series, length	.036		
P^1 , length (<i>i. e.</i> , antero-posterior diameter)	.0075		
“ width (<i>i. e.</i> , greatest transverse diameter)	.006		
P^2 , length	.008		
“ width	.0105		
P^3 , length	.0105		
“ width	.012		
P^4 , length	.011		
“ width	.0145		
Upper molar series, length	.035		
M^1 , length	.012		
“ width	.016		
M^2 , length	.013		
“ width	.017		
M^3 , length	.0115		
“ width	.0165		

	No. 9267.	No. 20.	No. 15,996.
Lower dentition, length i_3 - m_3	.0915		.089
I_3 , antero-posterior diameter	.0075		.008
" transverse diameter	.004		.003
Lower premolar-molar series, length	.074		.074
" premolar series, length	.038		.038
P_1 , length	.006		.005
" width	.003		.003
P_2 , length	.010		.010
" width	.006	.005	.005
P_3 , length	.011	.0115	.012
" width	.007	.0075	.008
P_4 , length	.011	.011	.0115
" width	.0085	.0095	.010
Lower molar series, length.	.036	.036	.036
M_1 , length	.011	.011	.0115
" width	.0095	.009	.009
M_2 , length	.012	.012	.013
" width	.0095	.009	.009
M_3 , length	.013	.014	.013
" width	.0085	.008	.008
Mandible, depth below p_3	.019		.017

Localities.—Not given for type; No. 15,996 was collected by Mr. Peterson, four miles south of Coy Inlet, and No. 9267 by Mr. Brown, but the locality record has unfortunately been lost.

PROTEROTHERIUM PERPOLITUM Ameghino.

(Plate IX, Fig. 9.)

Proterotherium perpolitum Amegh.; Enum. Synopt., etc., 1894, p. 36.

This species, which is very inadequately known from a single tooth (m^3 of the right side), may be distinct, or may be merely a variant of the preceding one. The type agrees closely in size with the corresponding tooth of *P. intermedium* and also in the very unusual character of having the two external cusps of almost equal width, but, on the other hand, the hypocone, which in *P. intermedium* is relatively very large, is entirely wanting in the present species, and thus the tooth has a somewhat triangular outline.

The type-specimen measures 11 mm. in antero-posterior, by 17 mm. in transverse diameter.

Locality.—Not given.

PROTEROTHERIUM CAVUM Ameghino.

(Plates VIII, Figs. 1-3; IX, Figs. 11, 11a; X, Figs. 15, 15a; XI, Figs. 9-9a.)

Proterotherium cavum Amegh.; Enum. sistem., etc., 1887, p. 19.*Diadiaphorus sanctæ-crucis* Lydderker; Anales del Museo de La Plata, T. II, 1893, p. 60.

This would appear to be the commonest and one of the most distinctly marked of the Santa Cruz species of the genus. It is characterized by small size, though in this respect there is much variability, and by the comparative simplicity of the upper premolars, p^3 and 4 having a smaller tetartocone, or postero-internal cusp, than in any of the preceding species. In m^3 the postero-external cusp (metacone) is less reduced than in most species of the genus, but narrower than the antero-external (paracone) and the hypocone is small, but it appears to be constantly present.

In the mandibular dentition, the canine is isolated by short, but distinct, diastemata in front of and behind it, and p_1 , though quite variable in size, is generally larger than in *P. intermedium* and is implanted by two roots.

In the table of measurements, No. 23 is a cast of an upper jaw in the Ameghino collection labelled "co-type"; No. 24 is the cast of a mandible, also labelled "co-type," but of a considerably smaller individual; No. 25 is a cast of an upper jaw of the same collection, while No. 26 is the cast of the mandibular dentition of a fourth individual referred to this species; No. 9245 is the skull in the American Museum of Natural History which is shown in Plates VIII, figs. 1 and 1a; IX, figs. 11, 11a. The identification of this skull is somewhat uncertain, as the teeth are so worn that the pattern is almost obliterated. The measurements of the type are taken from Ameghino ('89b, 561).

MEASUREMENTS.

	Type.	No. 23.	No. 25.	No. 9245.
Upper dentition, length i^2 - m^3		.099	.093	.101
I^2 , antero-posterior diameter		.006	.008	.006
" transverse diameter		.005	.008	.0055
Upper premolar-molar series, length	.075	.074	.0685	.076
" premolar series, length		.040	.0375	.0415
P^1 , length (<i>i. e.</i> , antero-posterior diameter).	.008	.009	.008	.010
" width (<i>i. e.</i> , greatest transverse diameter)	.007	.007	.009	.007
P^2 , length	.009	.010	.0085	.010
" width	.008	.011	.012	.0105

										<i>No.</i>		
										<i>9245.</i>		
										<i>Type.</i>	<i>No. 23.</i>	<i>No. 25.</i>
P ₃ , length	.	.	.	.	.	.	.	.	.	.009	.011	.0095
" width	.	.	.	.	.	.	.	.	.	.010	.014	.0145
P ₄ , length	.	.	.	.	.	.	.	.	.	.010	.011	.0115
" width	.	.	.	.	.	.	.	.	.	.013	.0145	.016
Upper molar series, length	.	.	.	.	.	.	.	.	.		.036	.033
M ₁ , length	.	.	.	.	.	.	.	.	.	.010	.0125	.011
" width	.	.	.	.	.	.	.	.	.	.016	.016	.017
M ₂ , length	.	.	.	.	.	.	.	.	.	.014	.013	.013
" width	.	.	.	.	.	.	.	.	.	.017	.017	.017
M ₃ , length	.	.	.	.	.	.	.	.	.	.012	.012	.010
" width	.	.	.	.	.	.	.	.	.	.015	.017	.018
										<i>No.</i>		
										<i>15,722.</i>		
I ₃ , antero-posterior diameter	.	.	.	.	.	.	.	.	.			.006
" transverse diameter	.	.	.	.	.	.	.	.	.			.004
Lower premolar-molar series, length	.	.	.	.	.	.	.	.	.	.079	.073	.080
" premolar series, length	.	.	.	.	.	.	.	.	.	.040	.036	.041
P ₁ , length	.	.	.	.	.	.	.	.	.	.007	.0065	.009
" width	.	.	.	.	.	.	.	.	.	.003	.004	.004
P ₂ , length	.	.	.	.	.	.	.	.	.	.0105	.011	.011
" width	.	.	.	.	.	.	.	.	.	.0055	.0065	.0055
P ₃ , length	.	.	.	.	.	.	.	.	.	.012	.011	.012
" width	.	.	.	.	.	.	.	.	.	.008	.008	.009
P ₄ , length	.	.	.	.	.	.	.	.	.	.011	.011	.0115
" width	.	.	.	.	.	.	.	.	.	.009	.010	.0105
Lower molar series, length	.	.	.	.	.	.	.	.	.	.039	.037	.039
M ₁ , length	.	.	.	.	.	.	.	.	.	.011	.0105	.011
" width	.	.	.	.	.	.	.	.	.	.009	.010	.010
M ₂ , length	.	.	.	.	.	.	.	.	.	.012	.011	.012
" width	.	.	.	.	.	.	.	.	.	.009	.010	.010
M ₃ , length	.	.	.	.	.	.	.	.	.	.014	.013	.016
" width	.	.	.	.	.	.	.	.	.	.009	.009	.0095

Quite a notable difference may be observed between Nos. 23 and 25 in regard to the proportions of the premolars, which are considerably shorter and broader in the latter.

In the succeeding table all of the measurements are taken from No. 9245.

MEASUREMENTS.

Skull, length in median basal line .	.168	Occiput, width at top	.029
“ “ condyle to premaxillary	.180	Cranium, width at constriction .	.032
Cranium, length condyle to anterior rim of orbit	.110	“ greatest width	.041
Face, length orbit to premaxillary .	.070	Zygomatic arch, length	.094
Occiput, height	.0575	Palate, length in median line .	.092
“ width at base	.047	“ width at p ¹	.020
		Face, width over lachrymals	.045
		Rostrum, width	.022

A fragmentary fore-limb, No. 15,728, not associated with skull or teeth, may be provisionally referred to this species. From this the following measurements were taken.

MEASUREMENTS.

Radius, distal width	.023	Metacarpal III, proximal width .	?.016
“ “ thickness	.0175	“ “ “ thickness .	.013
“ “ width over articular surface	.019	Phalanx I, digit III, length . .	.037
Radius, distal thickness over articular surface	.012	“ I, “ “ prox. width .	.020
Ulna, distal width	.007	“ I, “ “ “ thickness .	.012
“ “ thickness	.0105	“ 2, “ “ length	.0185
Carpus, length in median line .	.020	“ 2, “ “ prox. width .	.018
“ width	.025	“ 2, “ “ dist. width .	.017
Metacarpal II, proximal width .	.008	Ungual, digit III, length	.028
		“ “ “ greatest width .	.025
		“ “ “ prox. width .	.018

A fore-foot, lacking the phalanges, is associated with the mandible, No. 15,722, and, as the measurements of the teeth indicate, this was an animal of advanced age with unusually heavy grinding teeth. In the absence of the upper premolars, the reference is provisional only. This specimen is shown in Plate XI, fig. 9.

MEASUREMENTS.

Metacarpal II, proximal width .	.008	Metacarpal III, proximal thickness .	.012
“ “ “ thickness .	.012	“ “ distal width	.018
Metacarpal III, length	.069	Metacarpal IV, proximal width .	.007
“ “ proximal width	.016	“ “ “ thickness .	.0085

Localities.—The type-specimen was found in the cliffs of the Rio Santa Cruz; Nos. 15,722 and 15,728 were collected by Messrs. Hatcher and Peterson at Killik Aike, and No. 15,712 five miles south of Coy Inlet. In the collection of the American Museum, No. 9245 was obtained by Mr. Brown at Felton's Estancia, Rio Gallegos.

PROTEROTHERIUM NITENS Ameghino.

(Plate IX, Fig. 4.)

Proterotherium nitens Amegh.; Enum. Synopt., etc., 1894, p. 37.

The propriety of separating this species from *P. cavum* is very doubtful. It agrees well with the latter in stature and in tooth-pattern, especially in the diagnostic character of the small size of the tetartocone in p^3 and p^4 but differs in the absence of the hypocone in m^3 , and the small prominence of the external vertical crests, particularly of the mesostyle. This median ridge is quite obsolete in p^3 and p^4 and low and inconspicuous in the molars. The cast of the type-specimen, however, gives the impression that the jaw has been rolled and abraded and some of the teeth are more or less broken. Besides, such a character may well be individual rather than specific.

MEASUREMENTS.

Upper dentition, length	.068	P^4 , width	.013
" premolar-molar series, length	.037	Upper molar series, length	.031
P^1 , length (<i>i. e.</i> , ant.-post. diam.)	.0085	M^1 , length	.010
" width (<i>i. e.</i> , greatest trans. diam.)	.0075	" width	.017
P^2 , length	.0085	M^2 , length	.0115
" width	.010	" width	.0175
P^3 , length	.010	M^3 , length	.0095
" width	.012	" width	.017
P^4 , length	.011		

Localities.—Not given.

PROTEROTHERIUM KARAIKENSE Ameghino.

(Plate IX, Fig. 3.)

Proterotherium karaiense Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 299.

This is a well-defined species, in which the molar pattern more nearly approximates the perissodactyl type than in any other known Santa Cruz representative of the family. The type specimen is a fragment of the left maxillary, containing the five posterior teeth in intact and almost unworn condition. In p^3 the anterior conule is hardly indicated, the tetartocone is extremely small, and on the outer face the mesostyle is quite obsolete. P^4 is more completely molariform than in *P. cavum*, having a somewhat better developed tetartocone and more quadrate shape.

The perissodactyl similarity of the molar pattern is produced by the slight backward displacement of the posterior conule, bringing it into closer connection with the hypocone and opening the valley internally. When abraded, the tooth shows two transverse crests, which though incomplete, suggest those of *Meshippus* or *Anchitherium*. The hypocone is small in m^2 and absent in m^3 . In the latter, the posterior crest formed by the elevated cingulum does not reach the external wall and thus the longitudinal valley opens backward in quite peculiar fashion. On the outer wall of the molars the mesostyle is unusually low and the external cusps have but a slight concavity.

MEASUREMENTS.

P^3 , length (<i>i. e.</i> , ant.-post. diam.)	.011	M^1 , width	.0165
" width (<i>i. e.</i> , greatest trans. diam.)	.013	M^2 , length	.014
P^4 , length	.012	" width	.017
" width	.015	M^3 , length	.012
Upper molar series, length	.035	" width	.017
M^1 , length	.012		

Locality. — The specimens in the Ameghino collection were found at Kar Aike.

PROTEROTHERIUM POLITUM Ameghino.

(Plate IX, Fig. 10.)

Proterotherium politum Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 152.

This supposed species, represented by a single tooth, is quite indeterminate. No locality is given for the type.

PROTEROTHERIUM DODGEI sp. nov.

(Plates IX, Figs. 1, 1a, 5, 6; XI, Figs. 1-8; XII, Fig. 2.)

Among the material collected by Mr. Hatcher at Lake Pueyrredon is a species of *Proterotherium*, represented by two very fragmentary skeletons, which differs in significant details from any of the species previously described. There is reason to believe that the Santa Cruz beds displayed at Lake Pueyrredon represent a somewhat lower and older horizon than the beds along the Atlantic coast and it is therefore probable that we have to do here with actual specific mutations and not with mere contemporary variations.

The type of *P. dodgei* is a specimen (No. 15,107) consisting of the

facial region of a skull, with all of the upper teeth intact and in a moderately advanced state of wear, the hinder portions of the left ramus mandibuli, with the molars in place, and several limb- and foot-bones in a more or less incomplete condition, as figured in Pl. XI. The relatively large size of the tusks and the prominent cingulum of the grinding teeth, external in the upper teeth and internal in the lower, probably indicate that the animal was a male.

The upper dentition, so far as can be judged in its worn condition, does not differ in any important way from that of *P. australe*. P^1 is quite simple and has a low internal cingulum; p^3 and 4 have a large, well-developed postero-internal cusp (tetartocone), which gives the crown, especially of p^4 , a subquadrate outline. M^3 has a much reduced postero-external cusp (metacone) and the hypocone, which in *P. australe* is wanting, is small, but quite distinct. It is in the lower molars that the most distinctive features appear and, had these teeth alone been found, one would have had little hesitation in referring them to *Licaphrium*. As in that genus, the valleys are shallow, the crescents thick and massive, and the pillar in the posterior crescent is much larger and more conspicuous than in any of the foregoing species of *Proterotherium*.

MEASUREMENTS.

Upper dentition, length i^2 - m^3 . . .	.108	M^1 , length	.013
I^2 , antero-posterior diameter . . .	.0075	" width	.017
" transverse diameter	.007	M^2 , length	.014
Upper premolar-molar series, length . . .	.079	" width	.0185
" premolar series length	.044	M^3 , length	.012
P^1 , length (<i>i. e.</i> , antero-post. diam.) . . .	.0095	" width	.018
" width (<i>i. e.</i> , greatest trans. diam.) . . .	.007	Lower molar series, length . . .	.0415
P^2 , length	.0105	M^1 , length	.012
" width	.011	" width	.010
P^3 , length	.012	M^2 , length	.013
" width	.0135	" width	.011
P^4 , length	.013	M^3 , length	.016
" width	.016	" width	.010
Upper molar series, length	.037		

Most of the bones are in such a broken and crushed condition that accurate measurements are very difficult or quite impracticable. The dimensions in the following table are, however, close approximations to the truth.

Face, length from anterior rim of orbit	.078	Radius, proximal width	.016
Cranium, width at postorbital constriction	.033	“ distal width	.0185
Rostrum, width	.025	Femur, proximal width	.042
Palate, length in median line	.091	Tibia, length on inner side . . .	.133
“ width at p ¹	.022	“ distal width	.019
“ “ m ²	.027	Fibula, distal width	.004
Humerus, length from head	.128	“ “ thickness	.009
“ proximal thickness	.041	Astragalus, length	.032
“ distal width over trochlea	.018	“ width of trochlea	.018
“ distal width over epicondyles	.0295	“ “ distal end	.016
Radius, length	.113	Metacarpal II, proximal width . .	.008
		“ III, length	.068
		“ proximal width	.016

Locality.—Lake Pueyrredon.

This species is dedicated to Cleveland H. Dodge, Esq., of New York, whose oft-exercised liberality has been one of the main supports of the Patagonian work.

PROTEROTHERIUM ACRE (Ameghino).

(Plate VIII, Fig. 7.)

Heptaconus acer Ameg.; Énum. Synopt., etc., 1894, p. 44.

As was pointed out on a preceding page (p. 54) it frequently happens in various species of *Proterotherium* that a small enamel pillar makes its appearance, as a development of the cingulum, between the internal cusps of the upper molars. In most cases, however, this pillar is minute and very variable, differing much even in the opposite sides of the same jaw. One individual, shown in Plate X, fig. 1, and perhaps belonging to an undescribed species, has this pillar small, though very distinct on p⁴, m¹ and ², at least, as these are the only teeth with completely preserved crowns, and it may very well have been present in p³ and m³ also. In *Proterotherium acre* the pillar attains a large size, becoming nearly as large and prominent as the hypocone. So far, this species is known only from a single tooth, an upper molar of the left side, which measures 14 mm. in antero-posterior, by 19 mm. in transverse diameter.

Locality.—Not given.

TETRAMERORRHINUS Ameghino.

(Plate VII, Figs. 8-11.)

Tetramerorhinus Amegh.; Énum. Synopt., etc., 1894, p. 39.

Though very doubtful as to the propriety of separating this supposed genus from *Proterotherium*, I prefer to let it stand as distinct until more material shall have been obtained for deciding the question. In his original description Ameghino says of it: "Les os du nez sont formés par quatre pièces distinctes, les deux nasaux et deux autres os qu'on peut appeler des internasaux. À peu près vers le tiers en avant de leur jonction avec les frontaux, les nasaux se séparent formant comme les deux branches d'une fourche, entre lesquelles s'intercalent les os internasaux; ces os se prolongent très peu en avant des nasaux et terminent en pointe. Par la position que ces os occupent on ne peut pas les regarder comme les homologues des prénasaux de plusieurs mammifères" ('94a, pp. 39-40). Whether this structure represents anything more than an individual abnormality, remains to be determined.

TETRAMERORHINUS FORTIS Ameghino.

(Plate VII, Figs. 8, 9.)

Tetramerorhinus fortis Amegh.; Énum. Synopt., etc., 1894, p. 40.

The type and only known specimen of this species has teeth which are much worn, but display no significant difference from those of *Proterotherium australe*. The skull, as is clearly indicated in the cast, has been subjected to some vertical crushing and the "internasals" have been pushed down below the level of the nasals. The edges of the latter are smooth and rounded and the shape of the opening made by the depression is very nearly symmetrical, so that the structure is apparently not due to fracture from crushing. I am inclined to believe, however, that this is merely an abnormal individual of *P. australe*, but a larger number of specimens must be obtained before such a reference would be fully justified. The rostrum and whole nasal region are broader than is usual in *Proterotherium*, and the supraciliary ridges are more elevated above the brain-case.

The dimensions in the following table are taken from a cast of the typical and only known representative of the species.

MEASUREMENTS.

Upper dentition, length i^2 - m^3 . . .	.106	Upper premolar series, length . . .	.045
I^2 , antero-posterior diameter . . .	.0065	P^1 , length (<i>i. e.</i> , ant.-post. diam.) . .	.010
" transverse diameter . . .	.0065	" width (<i>i. e.</i> , greatest trans. diam.) . .	.009
Upper premolar-molar series, length . .	.082	P^2 , length	.0105

MEASUREMENTS.

P ² , width	.012	M ¹ , width	.0185
P ³ , length	.012	M ² , length	.014
" width	.016	" width	.019
P ⁴ , length	.014	M ³ , length	.0125
" width	.0175	" width	.019
Upper molar series, length	.039	Cranium, width at constriction	.036
M ¹ , length	.0125	Rostrum, width	.029

Locality. — Not given.

TETRAMERORHINUS LUCARIUS Ameghino.

(Plate VII, Figs. 10, 11.)

Tetramerorhinus lucarius Amegh.; Enum. Synopt., etc., 1894, p. 40.

The separation of this species from *Proterotherium* is of even more doubtful propriety than in the case of *T. fortis*, from which it differs in its decidedly smaller size. The teeth are very similar in size and structure to those of *Proterotherium cavum*, to which, it seems very probable, this species should be referred. Such differences in the tooth-pattern as may be noted are no greater than may well be regarded as mere individual variations. Thus, p² has a smaller and less prominent inner tubercle, while in p³ and ⁴ the postero-internal cusp (tetartocone) is somewhat larger.

Though unwilling to make any positive statement from the examination of a cast, I cannot but think that the division of the nasal bones, which is asymmetrical and irregular, is a result of the vertical down-crushing which the skull has evidently undergone. The somewhat unusual width of the rostrum is probably likewise a result of the same cause. Should, however, the division prove not to be due to crushing, it would go far to confirm Ameghino's interpretation, as it is very unlikely that individuals of different species should show the same abnormality.

MEASUREMENTS.

Upper premolar-molar series, length.	.0675	P ⁴ , length	.0105
" premolar series, length.	.036	" width	.013
P ¹ , length (<i>i. e.</i> , ant.-post. diam.)	.008	Upper molar series, length	.032
" width (<i>i. e.</i> , greatest trans. diam.)	.005	M ¹ , length	.011
P ² , length	.009	" width	.0155
" width	.008	M ² , length	.012
P ³ , length	.010	" width	.016
" width	.012	M ³ length	.010

Locality. — Not given.

TICHODON Ameghino.

(Plate VIII, Fig. 8.)

Tichodon Amegh.; Énum. Synopt., etc., 1894, p. 43.

TICHODON QUADRILOBUS Ameghino.

(Plate VIII, Fig. 8.)

Tichodon quadrilobus Amegh.; Énum. Synopt., etc., 1894, p. 43.

Known only from a single tooth and of quite indeterminate position. This tooth, m_3 of the left side, measures 14 mm. in antero-posterior, by 6.5 mm. in transverse diameter.

Locality. — Not given.

THOATHERIUM Ameghino.

(Plates XI, Fig. 12; XII, Figs. 3-13a; XIII-XV.)

Thoatherium Amegh.; Enumeracion sistematica, etc., 1887, p. 19.

Merycodon Mercerat; Rev. del Mus. de La Plata, T. I, 1891, p. 466 (*fide* Ameghino).

Rhagodon Mercerat; Ibid., p. 468 (*fide* Ameghino).

Proterotherium Lydekker, in part; Anales del Mus. de La Plata, T. II, 1893, p. 63.

This genus represents the extreme modification among the Proterotheriidae as regards digital reduction; indeed, it is the most completely monodactyl animal known, decidedly surpassing the horses in this respect. However, the relatively isolated position of the genus is shown not only in the feet, but in all parts of the skeleton also. It may be characterized as follows: (1) The upper lateral incisors are caniniform, but smaller than in any of the preceding genera. (2) In the upper molars the two internal cusps and the anterior conule are connected by a continuous crest, while the posterior conule is vestigial, or absent. (3) The lower lateral incisor is not caniniform and is hardly larger than the median. (4) The lower molars have no internal pillar and m_3 is without a talon. (5) The nasals are shorter than in *Proterotherium*, longer than in *Diadiaphorus*, and the dorsal portion of the occiput is remarkably narrow and projects far behind the plane of the condyles. (6) The limb-bones are all more slender and elongate than in any of the preceding genera and the ulna and fibula are more reduced. (7) The feet are strictly monodactyl, the lateral digits

being reduced to mere nodular vestiges of the proximal ends, and the metapodials are longer and more slender than in any other genus of the family.

Dentition. — (Pl. XIII, figs. 14–18.)

A. Upper Jaw. The upper incisor, though caniniform, is notably smaller than in *Proterotherium* and is somewhat more rounded and less trihedral in cross-section. Though young skulls with the milk-teeth are not uncommon, I have seen no skull with unworn premolars. When considerably worn the last three premolars have a narrow, triangular valley in the middle of the crown. While the elements of the molar crown are the same as in *Proterotherium*, yet the appearance is quite different; in m^1 and m^2 the anterior conule and the two internal cusps are connected by a continuous and somewhat longitudinal ridge, the various cusps projecting but slightly below the level of the crest and demarcated by very shallow vertical grooves. The apices of the cusps are very early worn away and then the tooth has merely a central enamel valley like that of the premolars. The posterior conule is greatly reduced and forms but a narrow and slender spur from the longitudinal ridge, which may or may not reach the outer wall of the crown. The third molar differs from the other two in the great reduction of the postero-external cusp, which is convex and more posterior than external in position; the postero-internal cusp is very small and separate from the antero-internal.

B. Lower Jaw. One of the characteristic features of *Thoatherium* is to be found in the relative size of the two lower incisors, the lateral being very little larger than the median, a marked distinction from all the other genera of the family. Both of the incisors are more procumbent than in *Proterotherium*, pointing almost directly forward. The canine and first premolar resemble those of the last named genus, but the second differs in the internal ridges, of which the anterior one is smaller and the posterior one larger. The third and fourth premolars are molariform. The molars resemble those of *Diadiaphorus* rather than those of *Proterotherium*, as they have no postero-internal pillar and m_3 has no talon, while the external angles of the crescents are more rounded and not so sharp.

Milk-Teeth. — The upper deciduous incisor is somewhat smaller than its successor and of rather more trihedral shape. After a short diastema this tooth is followed in some individuals, not in all, by a second, very small, premaxillary tooth, probably di^3 , which is acutely conical in shape. The

first upper milk-premolar (dp^1) is larger than p^1 ; its crown is made up of a very large external cordate cusp and two internal cusps, of which the anterior is very small and hardly more than a raised cingulum; on the outer side of the tooth, near the anterior border, is a deep vertical groove. The second upper temporary premolar is of similar pattern, but much larger and with better developed internal cusps. The third is like a molar, with two external cusps, but has a relatively greater antero-posterior elongation, while dp^4 is altogether molariform.

The difference in size between the median and lateral incisors of the mandible is even less in the temporary than in the permanent dentition and the milk-canine is smaller than its successor. In the premolar series, dp_1 is like p_1 , but dp_2 is larger than p_2 and has quite a different appearance; of the two internal cusps, the anterior one is better developed and the posterior one less so, while the ridge that runs back from the summit of the protoconid ceases at the postero-internal cusp, while in p_2 it is continued for the whole length of the crown. The last two milk-premolars differ from p_3 and p_4 only in their greater elongation antero-posteriorly.

Skull (Pls. XIII, fig. 12; XIV). — In general, the skull resembles that of *Proterotherium*, but is smaller, lighter, more slender and graceful, and there are several constant differences in details. In the first place, there are certain differences of proportion, which though not striking, are yet not without importance. The cranium is somewhat shorter and the face correspondingly longer, the orbit, which is relatively larger, having a rather more posterior position: the sagittal crest is considerably shorter and the temporal foramina have a conspicuously shorter antero-posterior diameter; the face tapers forward more gradually and the muzzle is narrower and more slender. Another and very characteristic difference is in the shape of the occiput, which is quite as broad at the base as in *Proterotherium*, but narrows rapidly, making the dorsal moiety extremely narrow and pointed, like a slender, lanceolate arch: this dorsal portion of the occiput projects backward much farther than in *Proterotherium*. The basioccipital is relatively broader than in the latter and has a better defined median keel and the occipital condyles are more widely separated ventrally.

The brain-case is shorter, fuller and more rounded than in *Proterotherium* and descends more abruptly behind, making the posterior part of the sagittal crest very much higher. The squamosal is much as in the latter genus, but the postglenoid process is shorter and has a more

swollen, mamillate appearance, and is more extensively invaded by the very large and conspicuous glenoid foramen : the zygomatic arch is shorter and its dorsal border is continued as a low ridge up to the sagittal crest, making a more definite posterior boundary to the temporal fossa. The very large lachrymal is more extended upon the face and has no spine ; the foramen is, as in *Diadiaphorus*, placed in front of the orbit, not on its rim, as it is in *Proterotherium*. The frontals are longer than in the latter, reaching farther behind the orbits, especially in the median line, where they extend farther between the divergent ends of the parietals. The sinuses are larger and cause more prominent protuberances on the forehead ; the superficial prominence on each side is divided into two parts by the vascular groove which runs forward from the supraorbital foramen. This arrangement, which is not well shown in very young skulls, becomes very conspicuous in old animals and gives a characteristic appearance to this region of the skull.

The nasals are considerably shorter than in *Proterotherium*, longer than in *Diadiaphorus* and, as in the former, they articulate with the premaxillæ, though the suture is shorter. Consequently, the anterior nares are intermediate in form between the two genera, being longer and more oblique than in *Proterotherium*, shorter and more vertical than in *Diadiaphorus*. Otherwise, the premaxillæ are much as in *Proterotherium*, but the incisive foramina are larger and the spines correspondingly longer, and in the edentulous region between the incisor and first premolar the palatal surface is not so contracted, nor so distinctly demarcated from the lateral surfaces. The facial, or preorbital, portion of the maxillary is lower dorso-ventrally than in *Proterotherium* ; the palatine processes extend forward between the premaxillæ so as to take part in the formation of the incisive foramina. The palate is of more uniform width than in the last named genus and less deeply concave ; the palatines are very long.

The mandible is very like that of *Proterotherium*, the differences being chiefly in the ascending ramus, the ventral border of which descends less below that of the horizontal ramus and thus the inferior profile of the jaw is less sinuous in this region ; the coronoid is more slender, recurved and tapering, and the sigmoid notch is much wider, while the masseteric fossa is shallower.

Vertebral Column and Ribs. — As already mentioned in the account of the family given on a previous page (p. 10) the vertebral formula is quite

uncertain. Of the present genus I have 4 cervical, 8 thoracic, 4 lumbar and 2 sacral vertebræ, most of them belonging to a single individual. A careful comparison of these with the complete back-bone of *Theosodon* makes it appear probable that the number was a little greater than in that genus; viz., C. 7, Th. 15, L. 6. All of the vertebræ preserved resemble the corresponding ones of *Proterotherium*, though much smaller and lighter, and there are many differences in points of minor importance.

The atlas (Pl. XII, figs. 3, 3a) is short, broad and high dorso-ventrally; the anterior cotyles are large, widely separated dorsally, but quite closely approximated ventrally, and slightly emarginated in the middle of the lateral border. The neural arch is thick and convex and the spine is reduced to a vestige. The posterior cotyles are small and nearly plane and are not connected with the fossa on the inferior arch, which is narrow and deeply concave, but quite short antero-posteriorly; the hyapophysis is a spine-like tubercle on the hinder edge of the inferior arch. The vertebrarterial canal is very short, opening anteriorly into a large fossa on the side of the neural arch, which is deeper and better defined than in the atlas of *Proterotherium*. The atlanteo-diapophysial notch shows no tendency to become a foramen, as there is no process from the anterior border.

The axis (Pl. XII, fig. 4) has a curiously shaped centrum; seen from below, it is of subquadrate outline, the anterior width exceeding the length. Anteriorly, the centrum is broad, much depressed and very thin dorso-ventrally, behind the transverse processes it narrows and thickens, making the posterior face trihedral; the ventral keel is well defined, though not very prominent. The anterior cotyles for the atlas are low and broad, of irregularly trapezoidal outline, the outer border exceeding the inner in dorso-ventral length: the articular surface is saddle-shaped, concave transversely and convex dorso-ventrally. When the atlas and axis are placed together, there appears to be a surprising lack of adjustment between the respective articular surfaces, which would necessitate the presence of unusually thick cartilages to make up for this. One's first suspicion naturally would be that the two bones belonged to different animals, but the conditions under which they were found seem to exclude such a possibility. The odontoid process is strikingly long and slender and of irregularly cylindrical shape, which is in marked contrast to the short and heavy process of *Diadiaphorus*. On each side of the base of the odontoid is a deep and narrow sulcus, separating it from the cotyles. The transverse

processes are very slender and each is perforated by a vertebrarterial canal so short as to be hardly more than a foramen. The neural canal is quite large, especially the anterior opening; the spine is so broken that its shape cannot be accurately determined, but evidently it was a large, more or less hatchet-shaped plate. The postzygapophyses are quite small.

The (?) fifth cervical (Plate XII, fig. 5) has a short, broad, moderately depressed and slightly opisthocœlous centrum; the transverse process is pierced in the normal way by the vertebrarterial canal, which is very much longer than in the atlas or axis, and the inferior lamella, which is well developed, is divided into anterior and posterior portions. The neural canal is relatively large and the spine is distinct, though short and slender, and inclined forward. The anterior zygapophyses are large and slightly concave, the posterior much smaller.

The only other cervical preserved is an uncharacteristic fragment of a centrum, noteworthy only for the obliquity of the posterior face.

In view of the great elongation of the limbs, the neck in *Thoatherium* is surprisingly short, considerably shorter than the skull, to the basal length of which it bears the proportion of 81 : 100, approximately.

As already mentioned, the number of thoracic vertebræ is quite uncertain, though the available evidence seems to indicate 15 as the more probable number. On this assumption, the thoracic region, measured in a straight line would stand in proportion to the skull as 160 : 100. The first thoracic vertebra has a small, somewhat depressed, trihedral centrum; the transverse process is short, but very broad and depressed, ending in a very large deeply concave facet for the tubercle of the first rib: the neural canal is large and the spine broad, heavy and, presumably, high, with moderate backward inclination. In *Diadiaphorus* even the second thoracic has a slender, tapering and relatively short spine, such as is found in the posterior cervicals of many ungulates. The prezygapophyses are of cervical type and the postzygapophyses quite like those of a lumbar vertebra, small, convex and semicylindrical, projecting from the sides of the neural arch: there are no metapophyses.

The second thoracic has a slightly smaller centrum than the first and considerably shorter and more rod-like transverse processes, which bear much smaller and but slightly concave facets for the tubercles of the second pair of ribs, while the neural canal and spine are similar to those of the first; the prezygapophyses are also similar, but smaller and less concave,

and bear low, spine-like, incipient metapophyses: on the other hand, the postzygapophyses are of the normal thoracic type, placed on the under surface of the neural arch and very large.

In the middle portion of the thorax (Pl. XII, fig. 7) the vertebræ have larger and more depressed centra, with kidney-shaped faces; the transverse processes are prominent, but short and rod-like, and the metapophyses are prominent; the neural canal is small and the spines have a remarkably strong backward inclination; the zygapophyses are long, extremely narrow and widely separated. In the posterior thoracic region (Pl. XII, fig. 8) the centra become longer, broader and more depressed, while the transverse processes are greatly reduced, becoming vestigial on the last two or three vertebræ. Curiously enough, on the last four or five vertebræ the transverse processes have no articulation with the ribs, which is not true of *Diadiaphorus* or *Theosodon*, but does occur in the Santa Cruz *Tyotheria*. Probably the final thoracic is the anticlinal vertebra, as in the two genera last named, and on what is presumably the antepenultimate vertebra the postzygapophyses assume the lumbar pattern.

It is exceedingly likely that there were six lumbar vertebræ, and the four preserved are the last and probably the first, third and fourth. Assuming the formula of six, the length of the loins is to that of the skull as 86:100, and the entire length of the trunk, measured around the curve of the spinal column, is 251, when the basal length of the skull is taken as 100. The anterior and median lumbar have long, rather slender and depressed centra, with distinct ventral keels, broad, plate-like and antroverted transverse processes, and broad spines with moderate forward inclination; the zygapophyses are cylindrical and interlocking, the metapophyses are greatly reduced and the neural canal is large. Compared with those of *Proterotherium*, these vertebræ are distinguished by their more slender transverse processes, the smaller metapophyses and the less inclined spines. The last lumbar (Pl. XII, fig. 9) is quite different from those described; it has a wide, very much depressed centrum, with broad anterior and extremely small posterior face; the transverse processes are very broad and each has on its anterior border near the centrum a small, slightly convex facet for the fifth vertebra, and on the posterior border a much larger, deeply concave surface for the prominent convexity on the pleurapophysis of the first sacral: each of these posterior facets is actually larger than the hinder face of the centrum. The neural canal is broad and the somewhat narrow

spine has but a slight forward inclination. Of the zygapophyses, the anterior ones are large, the posterior much smaller.

As in *Proterotherium*, the number of sacral vertebræ probably exceeded six, but only two are preserved, belonging to a very young animal with milk teeth. The first sacral has a broad, extremely depressed centrum, which narrows much posteriorly; the neural canal is very much smaller than that of the last lumbar, especially in the dorso-ventral diameter, and the arch is separated by a considerable interspace from that of the second vertebra, though this may be due to the immaturity of the animal, while the spine is merely a vestigial crest. The anterior zygapophyses are much reduced in size, though functional, and the posterior ones are minute. The pleurapophyses are large and heavy, supporting the ilia almost entirely, as the contact of these bones with the second vertebra is very limited. On the anterior face of each pleurapophysis is a large, prominent, convex and transversely oval facet for the concavity on the transverse process of the last lumbar.

The second sacral is much smaller than the first and it is evident that, as in *Proterotherium*, the sacrum becomes exceedingly slender posteriorly, with neural canal reduced to a minimum.

No caudals are known, but the conformation of the sacrum renders it almost certain that the tail was very short, as appears to have been the case in all the known Santa Cruz representatives of this family.

A few fragments of ribs indicate that the anterior ribs were compressed and plate-like, though quite slender, and the posterior ones more rounded and rod-like.

Appendicular Skeleton. — Of the fore limb-bones, only a few fragments have been preserved, the distal half of the humerus, the greater part of the radius, the proximal and distal ends of the ulna and most of the manus. Ameghino has, in addition, figured and partially described an almost complete manus (94*b*, p. 271, fig. 12), and thus a fairly adequate conception of the structure of the fore limb may be reached. On the whole, the limb- and foot-bones are much the same as in *Proterotherium*, but they are relatively more elongate and much more slender and graceful, and there are also certain other significant differences.

The humerus (Pl. XII, figs. 10, 10*a*) has a more slender shaft than in *Proterotherium*; the distal trochlea has the same simple, pulley-like character as in the latter, but the supratrochlear fossa is shallower and the

anconeal fossa is deeper, while the supinator ridge is almost entirely obsolete.

The fore-arm bones (Pl. XII, fig. 11) are separate throughout. The head of the radius is more compressed antero-posteriorly than in *Proterotherium* and has better distinguished facets for the various parts of the humeral trochlea, while the bicipital tubercle is more prominent; the proximal part of the shaft is likewise more compressed antero-posteriorly, but, for most of its length, the shaft is stouter than in the genus last mentioned; the distal end, however, is not so thick and the groove on its anterior face for the extensor tendons is much shallower and less clearly marked: the facets for the scaphoid and lunar are more deeply impressed, more distinctly separated, and have a greater dorso-palmar diameter in proportion to their width.

Of the ulna, we have only the proximal and distal ends; the olecranon is large, laterally compressed, thickened and slightly incurved at the proximal end; the proximal part of the shaft is stout and trihedral, but very probably it was greatly reduced for most of its length, as the distal end is relatively smaller than in *Proterotherium*, though it still retains a lateral articulation with the lunar.

The carpus (Pl. XI, fig. 12) is essentially the same as in the tridactyl genera of the family and still remains semi-taxeopod, the scaphoid articulating with the magnum, but the lunar excluded from the unciform. The modifications of the carpus, as compared with that of *Proterotherium*, are less than would be expected from the strictly monodactyl character of the manus, the differences being almost entirely in matters of minute detail. Indeed, there is even less difference in the shape and mutual connections of the carpal elements between *Thoatherium* and *Proterotherium* than between the latter and *Diadiaphorus*.

The scaphoid has proportions almost identical with those seen in *Proterotherium*, but differs slightly in the shape of its facets; the surface for the trapezoid notches the bone more deeply, giving a more nearly cuboidal shape to the distal extension which carries the magnum facet, while that for the trapezium is somewhat smaller.—The lunar is proportionately not quite so high and narrow as in *Proterotherium* and the proximal facet, for the radius, does not incline so steeply toward the internal side, and on the outer side of this facet is a very small, though distinctly marked, surface for the ulna, a facet which does not appear in *Proterotherium*. The

lunar articulates only with the magnum, the facet for which is somewhat less concave palmo-dorsally than in the genus last named. —The pyramidal, which is not yet definitely known in *Proterotherium*, is elongate proximo-distally and very narrow transversely, giving to the bone a scale-like shape; the proximal end bears a simply convex facet for the ulna, and the distal end a small concavity for the unciform. —Of the pisiform I have seen no example in either *Diadiaphorus* or *Proterotherium*; in *Thotherium* it is quite elongate, very slender near the proximal end, expanding toward the free end, which is also slightly thickened and incurved.

In none of the specimens which I have seen is the trapezium preserved, but the facet for that element upon the scaphoid demonstrates its presence and also that it was somewhat smaller than in *Proterotherium*. —The trapezoid is likewise rather smaller relatively than in the latter and differs in being shorter proximo-distally. —As in all the known members of the family, the magnum is the largest bone in the carpus; in form, it bears a general resemblance to that of *Proterotherium*, but is relatively somewhat lower in the proximo-distal dimension, wider transversely and shallower palmo-dorsally, which is chiefly due to the smaller size of the tuberosity on the palmar face. The proximal surface is almost equally divided between the facets for the scaphoid and lunar; the latter hardly rises so prominently above the former as it does in *Proterotherium* and is more saddle-shaped. On the distal portion of the radial side is a small, but distinct, facet for the second metacarpal. —The unciform is very small, especially in the transverse diameter; the proximal facet for the pyramidal is almost a groove on account of its concavity transversely: the distal end bears a small facet for the vestigial fourth metacarpal and a still smaller oblique surface for the head of the third. The hook-like process, which projects from the palmar face, is preserved, despite the very small size of the bone.

The metacarpus (Pls. XI, fig. 12; XIII, fig. 10) consists of a single functional member, mc. III, and two minute vestiges, which represent the proximal ends of mc. III and IV. Yet, notwithstanding this remarkably perfect monodactylism, which is more complete than in any other known mammal, the metacarpals retain their primitive connections with one another and with the carpus in a surprising manner. The reduction, complete and thoroughgoing as it is, is yet entirely of Kowalevsky's "inadaptive" type, and shows that Kowalevsky was mistaken in suppos-

ing that a foot-structure of perissodactyl symmetry did not admit of the inadapative method of reduction. As a matter of fact, however, this method has not been observed in any of the genuine Perissodactyla.

Metacarpal II is a mere vestige and consists only of the proximal portion of the original bone; the head is relatively large, both transversely and palmo-dorsally and quite extensively overlaps the head of mc. III, the facet for which presents distally and covers the radial portion of mc. III for its whole dorso-palmar diameter. The facet for the trapezoid occupies the entire proximal surface; that for the trapezium, which is relatively much smaller than in *Proterotherium*, is obliquely lateral in position. On the ulnar side is a facet for the magnum, and thus all the original connections are retained. — Metacarpal III, the only functional one of the series, is relatively longer and much more slender than that of *Proterotherium*. The proximal end is considerably expanded and is of nearly the same dimensions as in the smaller species of *Proterotherium*, but the following differences should be noted: (1) the facet overlapped by the head of mc. III is less oblique and more directly proximal; (2) the facet for the magnum is less simply concave transversely, becoming convex toward the ulnar side; (3) the unciform surface is much smaller and presents more proximally, less laterally; (4) the shaft is longer, more slender and rounded, less compressed palmo-dorsally. As in all of the members of this family, the carpal connections of mc. III are primitive, as the bone is excluded from contact with the trapezoid and touches the unciform only by a minute lateral facet. Although the functional metacarpal bears such a close general resemblance to that of the modern horse, it differs notably from the latter in mode of articulation with the carpus.

Mc. IV is a minute rudiment, measuring only 1 cm. in extreme length, and is a compressed, scale-like bone, tapering distally to a blunt point. These minute splint bones differ from those of the horse, not only in their very much smaller size, but also in their more lateral position: mc. II still retains its connection with the magnum, and excludes mc. III from the trapezoid

The proximal phalanx is much narrower and less depressed than that of *Proterotherium* and its distal trochlea is more grooved in the median line; the second phalanx also is much more slender, while the ungual is longer and narrower, more concave on the palmar face and with much more prominent median dorsal beak for the trochlea of the second phalanx.

The pelvis is represented by only a single specimen, derived from an immature animal and lacking the anterior portion of the iliac plate. The ilium, so far as it is preserved, resembles that of *Proterotherium*, but has an even shorter peduncle, from which the anterior expansion broadens out more abruptly; the ischial border is sharp and well defined, but the pubic border is very short and the acetabular border is obscure: the gluteal surface is but slightly concave and there is no ilio-pectineal spine, but there is a roughened tubercle at the anterior margin of the acetabulum, presumably for the attachment of the gluteus minimus muscle. The ischium is short, slender and laterally compressed, expanding posteriorly into a broad, thin and strongly everted plate, which bears a small tuberosity: the sciatic notch is very feebly indicated. The pubis is short, compressed and plate-like, but has a slender backward prolongation on the ventral side, which makes the symphysis long. The obturator foramen is a long, narrow oval, smaller than in *Proterotherium*.

The femur (Pl. XII, figs. 12, 12a) is remarkably equine in appearance, strongly resembling that of *Meshippus*. The head is small and placed upon a short, distinct neck, and is thus less sessile than in *Proterotherium*, more antroverted and with the pit for the round ligament less extended proximally, but of similar ovoid shape, with the long axis directed antero-posteriorly; while the bridge between the head and the great trochanter is more deeply notched. The great trochanter is much more prominent and rises much higher above the head than in the last named genus and the digital fossa, though hardly so deep, is more elongate; the second trochanter is a long, thin ridge, gradually dying away upon the shaft; its proximal portion is not so thickened and rugose as in *Proterotherium*; the third trochanter is rather less prominent and antroverted, but longer proximo-distally than in the latter. The shaft is moderately stout and has a slight sigmoid curvature; the linea aspera externa is less developed than in *Proterotherium*, but the fossa for the plantaris muscle is even deeper and more distinct. The rotular groove is narrower and slightly asymmetrical, owing to the somewhat greater elevation of the internal border, and there is a deep suprapatellar fossa. The condyles are widely separated and asymmetrical, the external one being larger and more convex; the articular surface is not continuous between the condyles and the rotular groove, but is interrupted by a narrow, non-articular space on each side.

The patella is rather short proximo-distally and relatively broad and

thick. It is shield-shaped, tapering to a blunt point at the distal end. The anterior face is somewhat rugose and the surface for the rotular groove of the femur is quite small and obscurely divided into two facets by a low intercondylar ridge.

The tibia (Pl. XII, figs. 13, 13a) is relatively longer and more slender than in *Proterotherium* and slightly exceeds the femur in length, exclusive of the great trochanter; the two parts of the bifid spine are even more widely separated than in the latter genus and the facets for the femoral condyles are of more unequal size, the external one being relatively larger; the cnemial crest is very prominent and heavy, but short, speedily dying away upon the shaft, and the sulcus for the extensor tendon is very deep and conspicuous; the proximal fibular facet is extremely small. The shaft is slender and has a distinct lateral sigmoid curvature. The distal end is narrow, the antero-posterior diameter exceeding the transverse; the distal fibular facet is very small and divided into two parts, one lateral and the other distal, the tibia extending over the fibula in a manner not seen in any of the preceding genera of the family, somewhat like that characteristic of the ruminant artiodactyls; the internal malleolus is much reduced and of little functional importance. The astragalar surface is much as in *Proterotherium*, but with certain differences: the fossa for the inner condyle of the astragalus is much shallower and the internal border much lower, the posterior intercondylar tongue is longer and narrower, while the facet on the anterior tongue for the pit on the neck of the astragalus is more distal. In certain individuals the astragalar surface is invaded from the inner side by a narrow, non-articular strip, which passes across the intercondylar ridge, but not the outer condyle. This sulcus, the distinctness of which varies much, is not present in any specimen of *Proterotherium* which I have examined.

In marked contrast with the distal end of the tibia in *Thoatherium* is that of the horse, with its broad, antero-posteriorly compressed shape, deeply concave facets for the astragalus, and very large and prominent internal malleolus, while the fibula is firmly ankylosed with the tibia: this structure is much better adapted to prevent dislocation than is the arrangement found in *Thoatherium*, in which indeed the structure would seem to be inadequate.

The fibula (Pl. XII, fig. 13) is much reduced and very slender, but shows no tendency to coalesce with the tibia; the shaft is irregular and

very thin and the expansion of the ends is chiefly in the antero-posterior direction; the sulcus for the peroneal tendon is even deeper than in *Proterotherium* and its recurved anterior border ends in a larger and more rugose tubercle. Anteriorly, the distal end extends somewhat beneath the tibia, a ruminant rather than a perissodactyl character; the facet for the calcaneum is elongate antero-posteriorly, but very narrow, and that for the astragalus is quite large and C-shaped and is principally confined to the anterior portion of the distal end.

Of particular interest is the pes (Pl. XIII, figs. 13, 13a) of *Thoatherium*, as showing the extreme of inadapative modification of the monodactyl foot, just as the horses display the extreme of adaptive monodactylism. Further, these fossils present us with an extraordinary case of convergent development, since no one, after a study of them, will be inclined to bring the Proterotheriidae into any close relations with the horses.

In the tarsus there is relatively little change from *Proterotherium*. The proportions of the astragalus as to length and width are the same as in the latter and form a strong contrast to the short, broad astragalus of the horse: the condyles have a slight obliquity, which varies in different individuals, and have narrower borders than in *Proterotherium*, while the articular surface is not reflected so far over upon the tibial side; the pit on the dorsal side of the neck for the anterior distal tongue of the tibia is shallower than in the latter and its distal border is less raised. The two parts of the ectal calcaneal facet meet at a more acute angle and the surface is much more deeply notched by an incision from the fibular side. The neck is shorter and the navicular facet is reflected farther upon the dorsal face along the fibular border; the sustentacular facet narrows more proximally, somewhat as in *Diadiaphorus*.

The calcaneum differs from that of *Proterotherium* in a number of particulars: the tuber, which is of the same relative length and similar form, is rather more compressed and slender, with less thickened and club-like free end, which has a straighter proximal border, owing to the less prominent projection of the ventral portion: the fibular facet is somewhat broader and less inclined toward the tibial side: the sustentaculum has a more abruptly truncated inner side and the distal end of its facet is carried up farther upon the body of the calcaneum: the distal end is considerably shallower planto-dorsally.

The navicular is like that of *Proterotherium*, but the plantar border of

the deeply concave astragalar surface is narrower transversely. I have not seen the entocuneiform, but Ameghino's figure ('94*b*, p. 270, fig. 11*D*) shows it to be a large, irregular, scale-like bone, shorter and wider than in *Proterotherium*. The mesocuneiform, which Ameghino has incorrectly supposed to be a vestigial first metatarsal ('94*b*, p. 270, explanation of fig. 11), is extremely small and even more reduced than in the genus last named. The very large ectocuneiform has a greater proximo-distal length in proportion to its width than that of *Proterotherium*, and the distal facet for mt. III differs in being L-shaped, one arm extending across the dorsal half and the other along the tibial side; in the angle between the two arms is a roughened, non-articular surface, thus making some approximation to the condition seen in the horses: on the plantar side is a small facet for the plantar hook of mt. III.

The cuboid differs in several respects from that of *Proterotherium*; the plantar hook projects more prominently backward, but does not descend so far distally, and on its tibial side is a long, narrow facet for the plantar hook of mt. III, a facet which has not been observed in any of the tri-dactyl genera of the family: the facet for mt. III, though still oblique, is more distal than lateral, and that for mt. IV, which is very much smaller, is shifted so as to be behind the surface for mt. III.

In the horses the tarsus forms a nearly closed ring, the entocuneiform and cuboid almost meeting on the plantar side, while in *Thoatherium* this tendency is but slightly indicated in the articulation of the cuboid with the plantar hook of mt. III.

The metatarsus, like the metacarpus, consists of one functional member, mt. III, while mt. II and IV are reduced to mere nodular vestiges; these vestiges are attached laterally to mt. III, though mt. IV is somewhat shifted to the plantar side, while in the horse the attachment of both splints is entirely plantar. Metatarsal II, as in *Proterotherium*, articulates with all three cuneiforms, excluding mt. III from contact with the mesocuneiform.

According to Ameghino's figures ('94*b*, pp. 271, 273, figs. 12, 13) metatarsal III is of the same length as the corresponding metacarpal; it is relatively much more elongate and slender than in *Proterotherium* and of a somewhat different shape, the head being broader with reference to the shaft, which is much more nearly cylindrical and less compressed planto-dorsally; the cuboid facet presents rather less laterally and more proximally, and that for the ectocuneiform is interrupted by a large non-articular surface,

corresponding to the similar area on the tarsal, as above described. A very marked difference from *Proterotherium* is in the large plantar hook, or beak, which in the latter genus projects very prominently backward, but rises very little above the ectocuneiform facet and has no articulation with the cuboid or ectocuneiform. In *Thoatherium*, on the other hand, the hook does not project so far backward, but rises far above the level of the proximal articular surface and bears upon its fibular side a long, narrow, oblique facet for the cuboid, and on the dorsal side is a very small, but prominently projecting facet for the ectocuneiform.

Metatarsal IV is a small nodule, tapering distally to a blunt point and articulating by small, plane facets with the cuboid and mt. III. Ameghino has figured a minute bone ('94*b*, p. 270, fig. 11*B*) attached to the fibular side of the cuboid, which he regards as a vestigial mt. V. In none of the specimens which I have examined is this bone retained, nor is there any facet for it upon the cuboid. I am therefore inclined to believe that this bone cannot be regarded as a normal member of the metatarsus, especially as nothing of the kind is indicated in any of the preceding genera of the family.

Phalanges are present only in the functional digit. The proximal phalanx is longer, much more slender and less flattened planto-dorsally than in *Proterotherium*; the groove of the proximal trochlea for the metatarsal carina is wider and has more sloping sides, and notches the dorsal border somewhat more deeply: the distal articular surface is not reflected so far upon the dorsal surface and narrows more proximally.

The second phalanx is also narrow and less depressed than in *Proterotherium*; the proximal trochlea is more deeply concave and the median dorsal beak is much more pronounced, while the distal trochlea is more concave transversely.

The ungual phalanx is longer, narrower, more pointed and much less depressed than that of the manus, and consequently has a much more convex dorsal surface; the proximal trochlea is obscurely divided into two condyles and has a smaller transverse and greater dorso-plantar diameter than that of the manus. Curiously, the hoofs of *Thoatherium* have a less equine appearance than those of the tridactyl genera, which is perhaps to be explained by the small size and lightness of the animal.

On a superficial examination, the pes of *Thoatherium* appears to be strikingly like that of the horse, but a closer study reveals a number of

very significant differences, which preclude any close association of the two families. (1) In *Thoatherium* the tarsus is fundamentally different; (a) the calcaneum retains its primitive connection with the fibula and is nearly intermediate in character between the artiodactyl and the perissodactyl type (the fibulo-calcaneal articulation of the horses has been secondarily acquired and is of an entirely different nature); (b) the astragalus is long and narrow and has a depressed-convex head for the navicular, which recalls that of the Condylarthra, and is widely removed from the cuboid, while its facet for the sustentaculum is very artiodactyl in character; (c) the navicular and ectocuneiform retain their relatively great proximo-distal length, very different from the low, broad, disc-like bones of the horse; (d) the cuboid and ectocuneiform are well separated on the plantar side.

(2) The mode of digital reduction is inadapative, mt. III being shut off from the greatly reduced mesocuneiform, which, though almost atrophied, is not ankylosed with either of the adjoining bones; the cuboid surface is oblique, as much lateral as proximal, while the ectocuneiform surface is much less extensive than in the horse. In the horses, mt. III articulates with all the distal tarsal bones by surfaces which present proximally and which are so arranged as to cover almost all the periphery of the proximal end, and there is no plantar hook. In *Thoatherium* these facets form less than a semicircle, though this is, to a certain extent, compensated for by the great hook which arises from the plantar side and articulates with the cuboid and ectocuneiform. In brief, the Litopterna have solved the problem of monodactylism in a manner which is distinctly different from that followed by the Perissodactyla.

Restoration (Pl. XV).—The lightness and grace of *Thoatherium* are conspicuous features. The head is smaller and lighter, proportionately somewhat longer than in *Diadiaphorus* (see Plate I), but of more slender shape and much shallower dorso-ventrally. The neck is strikingly short, which is made all the more conspicuous by the elongation of the limbs. The length of the trunk remains largely conjectural and the appearance of the skeleton, as given in Plate XV, might be materially changed by the discovery of a complete vertebral column. From the evidence now available, it seems very likely that the trunk was intermediate in relative length between the artiodactyl and the perissodactyl type, a little longer than in the former and slightly shorter than in the latter. The remains preserved

indicate a moderately elongate thorax and a short lumbar region. That the tail was short, is made evident by the character of the sacrum. The limbs are long and slender, much more so than in any other known representative of the family and, in particular, the feet are much more elongate than in any of the preceding genera. Limbs and feet have a strong, though superficial, resemblance to the horses and, as frequently emphasized, the feet are more strictly monodactyl than in any other known mammal. The equine likeness is confined to the appendicular skeleton; there is little in the skull and still less in the vertebral column to suggest such likeness.

Species. — In strong contrast to *Proterotherium*, *Thoatherium* is not characterized by great variability or by numerous species, well or ill defined. Only one species is at all well known and the others which have been named are founded upon very imperfect material.

THOATHERIUM MINUSCULUM Ameghino.

(Plates XI, Fig. 12; XII, Figs. 3-13a; XIII, Figs. 1, 2, 5, 10-18; XIV, XV.)

Thoatherium minusculum Amegh.; Enum. sistem., etc., 1887, p. 19.

Merycodon rusticus Mercerat; Rev. del Mus. de La Plata, T. I, 1891, p. 467 (*fide* Ameghino).

Merycodon Damesi Mercerat; Ibid. (*fide* Ameghino).

Rhagodon gracilis Mercerat; Ibid., p. 468 (*fide* Ameghino).

Thoatherium crepidatum Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 297.

Proterotherium cavum Lydekker (*non* Amegh.); Anales del Mus. de La Plata, T. II, 1893, p. 63.

Thoatherium rhabdodon Amegh.; Énum. Synopt., etc., 1894, p. 45.

By far the most abundant and the only well known species of the genus is *T. minusculum*. As the generic description has been taken almost entirely from this species, it is unnecessary to repeat the account here. It may be added, however, that unworn examples of m^3 show that the hypocone is absent and that the very large protocone is separate from the posterior transverse cingulum, though there is some variability in the pattern of this tooth. *T. crepidatum* and *T. rhabdodon* differ from *T. minusculum* only in the development of the basal cingulum, a very untrustworthy criterion. In the table, No. 62 is the cast of a mandible in the Ameghino collection labeled "*T. minusculum*, co-type"; No. 60, a cast of fragmentary upper and lower jaws referred to the same species; No. 66, a cast

of the type of *T. crepidatum*, and No. 69, a cast of a second individual with similar reference, while No. 75 is from the type of *T. rhabdodon*. All these casts are from originals in the Ameghino collection. No. 15,721 is the skull of a very old animal. No. 15,714 is the mandible of an old animal and No. 15,719 an animal at maturity.

MEASUREMENTS.

	No. 62.	No. 60.	No. 66.	No. 69.	No. 75.	No. 15,240.	No. 15,721.	No. 15,714.	No. 15,719.
Upper dentition, length i^2-m^2 .				.100		.100	.094		
Upper cheek-teeth series, length .			.070	.073		.072			
Upper premolar series, length .			.036	.038		.037			
P ¹ , length . .			.007	.0085	.008	.008			
" width . .			.007	.007	.007	.007			
P ² , length . .		.008	.009	.009	.009	.0085			
" width . .		.009	.010	.010	.0095	.010			
P ³ , length . .		.010	.010	.010		.0095			
" width . .		.012	.012	.013		.012			
P ⁴ , length . .		.011	.011	.011	.0115	.010	.010		
" width . .			.014	.014	.0135	.013	.0125		
Upper molar series, length . . .		.035	.035	.036		.034	.031		
M ¹ , length . .		.012	.012	.0115	.0115	.010	.0095		
" width . .		.014	.014	.015	.014	.015	.014		
M ² , length . .		.013	.014	.013		.012	.011		
" width . .		.016	.017	.016		.016	.015		
M ³ , length . .		.013	.0125	.0125		.012	.0105		
" width . .		.016	.015	.015		.015	.015		
Lower dentition, length, i_3-m_3 .	.090			.092			.091	.091	
Lower cheek-teeth series, length .	.070			.073			.073	.076	
Lower premolar series, length .	.034			.036			.036	.037	
P ₁ , length . .	.007			.006			.006	.0065	
" width . .	.004			.004			.004	.004	
P ₂ , length . .	.009			.009			.010	.0105	
" width . .	.0055			.006			.005	.006	
P ₃ , length . .	.0095			.0105			.0105	.011	
" width . .	.008			.0075			.008	.008	
P ₄ , length . .	.0115			.012			.011	.0115	

	No.	No.	No.	No.	No.	No.	No.	No.
	62.	60.	66.	69.	75.	15,240.	15,721.	15,719.
P ₄ width . . .	.008			.009			.008	.009
Lower molar series,								
length . . .	.036			.037			.037	.039
M ₁ , length . . .	.010			.0105			.0105	.0115
" width . . .	.008			.0085			.008	.009
M ₂ , length . . .	.012	.013		.0125			.013	.0135
" width . . .	.009	.0095		.0085			.009	.0095
M ₃ , length . . .	.014	.014		.014			.013	.014
" width . . .	.009	.008		.008			.008	.008

The dimensions of the skull in the following table are taken from No. 15,721, a rather small and very old individual, which had lost the anterior premolars (p¹-p³) during life, and those of the mandible from No. 15,719, a much younger animal, in which m₃ had just come into use.

MEASUREMENTS.

Skull, median basal length . . .	.150	Forehead, width over middle of orbits . . .	.057
" length condyles to premax. . .	.162	Face, width over lachrymals . . .	.051
" extreme length . . .	.181	Rostrum, width . . .	.023
Cranium, length condyles to anterior rim of orbit . . .	.093	Palate, length in median line . . .	.085
Cranium, width at postorbital constriction . . .	.035	" width at m ² . . .	.023
Cranium, greatest width . . .	.041	Mandible, length . . .	.139
Occiput, height . . .	.053	" " angle to m ₃ . . .	.048
" width at base . . .	.047	" height of coronoid . . .	.079
" " over condyles . . .	.031	" " condyle . . .	.063
" " at top . . .	.015	" length of symphysis . . .	.028
Face, length orbit to premaxilla . . .	.078	" depth below p ₃ . . .	.019
		" " m ₃ . . .	.024

A comparison of these dimensions with the corresponding ones of *Proterotherium cavum* (p. 76) will show how different are the proportions of the two skulls.

The measurements of the vertebræ given below are derived from three individuals, Nos. 15,719, 15,721, and 15,722, all of which agree closely in size.

MEASUREMENTS.

Atlas, length . . .	.0295	Atlas, dorso-ventral height . . .	.029
" width over ant. cotyles . . .	.034	Axis, length excl. odontoid . . .	.027
" " " post. " . . .	.034	" " incl. " . . .	.038
" " " trans. processes . . .	.047	" width of anterior face . . .	.030

MEASUREMENTS.

Axis, width of posterior face . . .	.015	? Fourth lumbar, length of centrum .	.027
? Fifth cervical, length of centrum .	.019	“ “ width of post. face .	.021
“ “ width of anterior face .	.014	Last lumbar, length of centrum .	.018
“ “ “ post. face .	.016	“ “ width of anterior face .	.019
Median thoracic, length of centrum .	.020	“ “ “ posterior face .	.013
“ “ width of ant. face .	.016		

The fore-limb is very incompletely represented in the collections and the following measurements were taken from several individuals.

MEASUREMENTS.

Humerus, distal width over trochlea .	.016	Radius, distal thickness . . .	.006
“ “ “ “ epicond. .	.024	Carpus, length in median line .	.0175
Ulna, length of olecranon . . .	.034	“ width	.020
“ distal width	.009	Metacarpal II, proximal width .	.006
“ “ thickness	.006	“ III, “ “	.016
Radius, proximal width	.016	“ “ “ thickness	.012
“ “ thickness	.009	“ IV, length	.010
“ distal width	.017	“ “ proximal width	.004

The measurements of the hind-limb are taken from a single individual, No. 15,719.

MEASUREMENTS.

Femur, length from head	.141	Metatarsal III, proximal width .	.017
“ “ “ gr't trochanter .	.159	“ “ proximal thickness .	.017
“ proximal width	.039	“ “ distal width	.017
“ distal width	.034	“ IV, length	.011
“ “ thickness over cond. .	.041	“ “ proximal width	.0025
Tibia, length, excl. spine	.143	Phalanx I, digit III, length . .	.037
“ proximal width	.034	“ I, “ “ prox. width	.0165
“ distal width	.019	“ I, “ “ “ thickness	.012
“ “ thickness	.020	“ I, “ “ distal width	.0125
Fibula, distal width	.008	“ 2, “ “ proximal width	.0135
“ “ thickness	.013	“ 2, “ “ distal width	.0125
Calcaneum, length	.056	“ 2, “ “ length	.025
Astragalus, length	.0285	“ 3, “ “ width of trochlea	.014
“ width of trochlea	.016	“ 3, “ “ greatest width	.016
“ “ “ distal end	.014	Phalanx 3, digit III, length (plantar side)	.018
Ectocuneiform, length	.008	Pes, length in median line	.193
“ width	.0145		
Metatarsal III, length	.083		

Localities. — The type-specimen was found in the cliffs of the Rio Santa Cruz and the numerous individuals brought home by Messrs. Hatcher &

Peterson were all obtained on or near the Atlantic coast ; at Coy Inlet, five or ten miles south of that inlet ; at Killik Aike on the Rio Gallegos and two miles west of that point, and at Halliday's Ranch, near North Gallegos.

Ameghino has named several species upon very incomplete material, which are listed below.

THOATHERIUM VELATUM Ameghino.

(Plate XIII, Figs. 3, 4.)

Thoatherium velatum Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 460.

Type, an incomplete cranium and isolated teeth. Characterized by the small size of the hypocone in m^1 and 2 and the absence of a distinct posterior conule in all the upper molars. M^3 has no hypocone and the protocone is connected with the postero-external angle of the crown by a curved crest. This species is somewhat larger than *T. minusculum*, m^2 measuring 15 mm. in antero-posterior by 17 mm. in transverse diameter, and in m^3 these dimensions are 13 by 17 mm.

Locality. — Rio Santa Cruz.

THOATHERIUM KARAIKENSE Ameghino.

(Plate XIII, Fig. 6.)

Thoatherium karaikense Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 454.

Type, a fragment of the left maxillary with m^3 in place. This species differs from the preceding ones in the larger size of the hypocone, which is present on m^3 as an isolated pillar, separated from the protocone and the external wall. This tooth measures 13 mm. antero-posteriorly by 16 mm. transversely.

Locality. — Kar Aike.

THOATHERIUM BILOBATUM Ameghino.

(Plate XIII, Fig. 7.)

Thoatherium bilobatum Amegh.; Anales del Mus. Nac. de Buenos Aires, Ser. 3, T. III, p. 459.

Locality. — not given.

MACRAUCHENIDÆ.

The second family of Santa Cruz Litopterna is that of the Macrauchenidæ, which differ markedly in almost all points of structure from the Proterotheriidæ, yet with such unmistakable fundamental similarity as to leave no question as to the propriety of referring both families to the same order.

Aside from the little known and still problematical genus *Adianthus*, the Santa Cruz representatives of the present family, so far discovered, all belong to a single genus, *Theosodon*, which may be regarded, with great probability, as directly ancestral to the Pampean genus *Macrauchenia*. In what follows, except with regard to the dentition, no account is taken of *Adianthus*, of which only the teeth are known, and the fact that it was a small animal.

The species of *Theosodon* are much larger animals than the contemporary Proterotheriidæ and of very different appearance and proportions.

In the present family there is no reduction in the number of teeth, the formula being $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$, and there is no enlargement of incisors or canines to form tusks. The first five teeth, from $i1$ to $p1$, inclusive, are a series with simple, recurved, compressed-conical crowns, which have a curiously reptilian, almost crocodilian appearance. The second and third premolars are smaller and simpler than the molars, while the fourth upper premolar is nearly, and the fourth lower quite, molariform. The pattern of the upper molars is, at first sight, very different from that of the Proterotheriidæ, but a closer examination reveals the identity of plan. As in the latter family, the brachyodont crown consists of two external, concave crescents, and two more or less conical internal cusps, the peculiarity of pattern arising from the development of accessory crests and ridges and the great elevation of the cingulum at the antero-internal angle. In moderately worn teeth two or three enamel lakes are characteristic. The lower molars are very similar to those of the Proterotheriidæ and are made up of two crescents, in the posterior one of which is a very conspicuous pillar, connected with the external wall by a spur. In *Adianthus* this element is absent.

The antemolars all have predecessors in the temporary series and the milk-teeth, are, in general, like their permanent successors and only the last deciduous premolar, in each jaw, has the molar pattern.

The skull is long and narrow, with slender brain-case and rather short

but quite prominent sagittal crest. The tympanic bone is very small, scale-like and flattened, not forming a bulla, and with an irregular meatus, which is not prolonged into a tube. The orbits are partially open behind and the horizontal rami of the mandible are very slender. The especial peculiarity of the skull is, however, to be found in the great reduction of the nasals and elongation of the anterior nares, which indicate the presence of at least an incipient proboscis.

The neck is very long, in striking contrast to the short neck of the Proterotheriidæ, yet the odontoid process of the axis retains its primitive, peg-like shape. In no other ungulate with a neck of comparable length, does the odontoid fail to assume the concave, spout-shaped form. All the cervical vertebræ, except the atlas, are greatly elongated and much resemble those of the camel and, as in the latter, the vertebrarterial canal traverses the neural arch, except in the first and sixth vertebræ, in which it still perforates the transverse process. Thus the shifting of the position of the arterial canal is not so complete as it afterwards became in *Macrauchenia*. The number of trunk-vertebræ, though not yet known with complete certainty, should very probably be stated as nineteen, 13-14 thoracics and 5-6 lumbar, another difference from the Proterotheriidæ, in which the number can hardly have been less than twenty-one. As in the latter family, the long, tapering sacrum is indicative of a very short tail. The sternum is very peculiar; the presternum and anterior segments of the mesosternum are long, very narrow and deep dorso-ventrally, while the hinder segments of the mesosternum are broad and depressed.

The limbs are long and slender and the limb-segments are proportioned differently from those of the Proterotheriidæ; the upper arm is short and the fore-arm long, the thigh long and the leg short. The scapula is broad and has a large acromion and very large metacromion, the latter about midway in the course of the spine. The fore-arm bones are separate in the Santa Cruz genus and the ulna is relatively heavy, the radius quite slender. The long femur has a very large great trochanter and a well-developed third trochanter, both of which are much more prominent in the Santa Cruz than in the later representatives of the family. The leg-bones, which have coalesced in *Macrauchenia*, are separate in *Theosodon* and the fibula is quite slender.

The feet are very different in appearance from those of the Protero-

theriidæ; the carpus has a similar semi-taxeopod arrangement, the peculiar overlapping of the pyramidal upon the magnum seen in *Macrauchenia* having not yet come about and the contact being still entirely lateral. The metapodials are relatively longer and the phalanges shorter than in the preceding family (except *Thoatherium*), and the unguals are short, broad and heavy, not in the least equine in character. The feet are tri-dactyl and nearly isodactyl, the three digits being of nearly equal length and thickness. The tarsus is closely similar to that of the Proterotheriidæ, but the astragalus has a slightly more perissodactyl appearance in the less convex and more depressed head.

In the Santa Cruz beds only two genera have been found which are referable to the Macrauchenidæ and one of these, *Adianthus*, may prove, when better known, to be more properly assignable to a different family. This Ameghino has already proposed ('94a, 27), but until the genus is more completely understood, it seems an unnecessary complication.

1. Size of animal larger; lower molars with very conspicuous pillar and spur in posterior crescent. *Theosodon*.
2. Animal very much smaller; lower molars without pillar or spur in either crescent. *Adianthus*.

THEOSODON Ameghino.

(Plates XVI-XX.)

Theosodon Ameghino; Enumeracion sistematica, etc., 1887, p. 19.

? *Pseudocælosoma* Ameghino; Rev. Argent. de Hist. Nat., T. I, 1891, p. 294.

Oxydontotherium Lydekker (*non* Amegh.); Anales del Mus. de La Plata, T. II, 1893, p. 65.

This genus which is the only well known Santa Cruz representative of the family, is one of the commoner elements of the Santa Cruz fauna and is quite fully represented in all the collections; it is thus now possible to make out almost every detail of dental and skeletal structure. Throughout, there is a close resemblance to the much later Pampean genus, *Macrauchenia*, though, on the other hand, there are many important modifications, especially of the skull, in the latter.

Dentition (Pls. XVII, figs. 1, 1a, 3, 3a, 4; XVIII, 1, 1a; XX, 1, 1a).

—The dentition is complete and unreduced, having the formula, $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$, = 44.

A. Upper Jaw. The incisors are arranged in an almost straight, antero-

posterior line and, though somewhat spaced apart, are yet inserted in an imbricating manner; the two median incisors of the opposite sides are separated by a wider space than any of the others. As already indicated in the description of the family, the first five teeth, from i^1 to p^1 inclusive, form a series of similar shape, but gradually increasing in size posteriorly. The crowns are of compressed conical form, with trenchant edges and acute points, and curve inward and slightly backward; the internal cingulum is feebly developed near the anterior and posterior margins. The canine differs from the incisors merely in being somewhat larger. Lydekker states ('93, 66) that the upper canine has two roots, but this must be merely an individual abnormality; in all of the numerous specimens that I have examined, this tooth is single-rooted. My observations thus agree with those of Ameghino ('94*b*, 281).

The first premolar is isolated by very short diastemata in front of and behind it and is implanted by a single, heavy root; it resembles the canine in form, but is decidedly larger, especially in antero-posterior diameter, and has a complete internal cingulum. I have seen no perfectly unworn examples of p^2 and 3 , but in the former the composition of the crown is plain, even in much worn specimens of the tooth; it consists of a single outer lobe, with pointed, cordate external face and a distinct external cingulum, and a single, crescentic inner lobe, which appears to be merely a greatly developed and complete internal cingulum; at all events, no other internal cingulum is present. The tooth is inserted by two massive roots. Premolar 3 is larger than p^2 , but, so far as can be judged from the much worn teeth at my disposal, the crown is composed of the same elements, although the inner crescent is not so regularly developed, being enlarged and broadened at the postero-internal angle, thus giving a more asymmetrical shape to the crown. On the other hand, the fourth premolar is almost molariform; it has two external, crescentic lobes, which are concave outward, but differs from the molars in having only a single principal internal cusp, the deuterococone. The anterior conule is represented by a ridge, which extends from the deuterococone to the antero-external angle of the crown. In perfectly unworn teeth, this ridge rises to an acute point, separated by a cleft from the deuterococone, but this cleft is obliterated in an early stage of wear and then the ridge appears to be a direct outgrowth from the deuterococone. In front of and behind the deuterococone, the cingulum is much elevated and encloses two large,

enamel-lined fossettes, which, in the process of attrition, long remain as enamel lakes. In advanced stages of wear, this tooth appears to have quite the crown-pattern of a molar, though in unworn teeth the difference is sufficiently obvious.

The molars are highly characteristic and form a rather short series; m^1 and 2 are of nearly the same size, the former being, in some cases, slightly wider transversely and shorter antero-posteriorly, though in others, m^2 is a little the larger in both dimensions, while, in all cases, m^3 is considerably the smallest of the series. The molar-pattern consists of two outer crescents, which are quite deeply concave externally and meet in a prominent median external pillar, or mesostyle; and, further, there are two small, conical, inner cusps, which are separated internally by a deep fissure, or narrow valley, but are confluent on their outer margins (*i. e.*, toward the external side of the crown). Intermediate conules are present; the anterior one, as in p^4 , is a ridge, rising to an acute point, which is demarcated from the antero-internal cusp (protocone) by a cleft (*i. e.*, in quite unworn teeth), while the posterior conule is a ridge, sloping uninterruptedly outward and backward from the postero-internal cusp (hypocone). A spur of enamel extends from the hypocone transversely to the outer wall of the crown, dividing the longitudinal valley into two fossettes, and in some individuals, another spur projects from the postero-external cusp into the posterior fossette, but this is a very variable feature. A third fossette is enclosed between the much elevated anterior cingulum and the protocone and anterior conule, and, in certain cases, a fourth and much smaller fossette is formed between the two internal cusps and the internal cingulum. This cingulum is, however, subject to great variation, and may differ in degree of development on the opposite sides of the same individual. In most of the skulls the internal cingulum is entirely absent between the two internal cusps (proto- and hypocones) and, when present, it may be a separate pillar, or a ridge connecting the two cusps and completely enclosing a fossette, or it may be attached to one cusp and not to the other, making an imperfect fossette, which opens inward by a narrow fissure (see Pl. XVII, figs. 3, 3a). Always this cingulum, when present, appears to be confined to m^1 and 2 ; I have seen no instance of its development in m^3 . Variable as it is, this character can hardly have the generic significance which Ameghino attributes to it.

The third upper molar is distinctly smaller than m^1 or 2 , the reduction

chiefly affecting the posterior half of the crown. The postero-external cusp is much smaller than the antero-external and is no longer in the same fore-and-aft plane with it, but is so inclined as to present backward rather than outward.

The roots of all the upper molars are peculiar; there are two external roots of the usual character, and one very large internal root, which is laterally compressed, but extends through the whole antero-posterior length of the crown, and shows distinct indications of being formed by the coalescence of two separate roots, of which the anterior is much the larger. The coalescence is by means of a thin sheet of dentine and cement, the two nerve-canals remaining separate.

In partially worn examples of the upper molars the various elements of the crown-pattern can no longer be distinguished; the longitudinal valley and the anterior and posterior fossettes remain as enamel lakes. In more advanced stages of attrition the anterior part of the valley is worn away and only two lakes are left, except in those cases in which a third small lake is enclosed between the two internal cusps and the cingulum. In very old individuals, of course, the lakes and all other elements disappear, with the exception of the surrounding wall of enamel.

B. Lower Jaw. The lower teeth have somewhat less complex patterns than the upper. The first seven teeth, from i_1 to p_3 inclusive, form a series of similar shape, increasing gradually in size and complexity backward. The incisors are simple, compressed conical teeth, with crowns which resemble those of the upper jaw in shape, but are somewhat lower and broader and have a better developed internal cingulum. The median incisors of the two halves of the mandible are almost in contact and bite between the two corresponding upper teeth. The first and second incisors, and sometimes the third also, are so inserted in the jaw that their principal diameter is transverse. The canine is like the incisors, except in being larger.

The first lower premolar may be described as an enlarged canine, and is single-rooted; p_2 , which is inserted by two roots, is still of the same general form, though of larger size, and has a much more prominent internal cingulum, which encloses small anterior and posterior basal fossettes. The third premolar is much more elongated antero-posteriorly than p_2 and shows the beginning of the bicrescentic pattern. Externally the crown has but a single, undivided cusp, but on the inner side, a prominent

vertical ridge, or incipient deuteroconid, divides the surface into two shallow concavities. The cingulum, both internally and externally, is more prominent than in p_2 . The fourth premolar is quite molariform, and is composed of two crescents, but there is no pillar or spur in the internal concavity of the posterior crescent, and the internal cingulum opposite the openings of the crescents is better developed.

The lower molars form a series nearly equalling in antero-posterior length the premolar series, m_2 is the largest and m_3 the smallest of the three. All have the same crown-pattern, with two antero-posteriorly directed crescents, opening inward; in the inner opening of the posterior crescent is a conspicuous spur, which, in perfectly unworn teeth, is seen to be a vertical pillar, connected with the external wall by an obscurely serrate ridge, above the level of which the unabraded apex of the pillar rises. In such teeth, it may be plainly seen that the forward crescent is shorter antero-posteriorly and more elevated dorso-ventrally than the hinder one, though the difference in height is speedily obliterated by wear.

Milk Dentition (Pls. XVII, figs., 3, 3a; XVIII, 1, 1a). — The temporary teeth differ but little in form from their permanent successors and are 32 in number; the formula is: $Di\frac{3}{2}$, $Dc\frac{1}{1}$, $Dp\frac{4}{4}$, all of them being changed.

A. Upper Jaw. The deciduous incisors are much smaller than the permanent ones, with crowns which are lower vertically, but relatively more elongate antero-posteriorly than the latter and acutely pointed. The canine is of the same shape as the incisors, but larger. The first milk-premolar is an enlarged canine in form, but differs from its permanent successor in having two roots, which demonstrates that all of the teeth of the temporary series are shed and replaced. The second milk-premolar differs somewhat in form in different species. In *T. lallemandi* it is considerably smaller than p_2 , though of similar pattern, and has a single internal crescent, formed by the elevated cingulum; in *T. lydekkeri* it is more like p_3 in form and has two internal crescents, of which the posterior is very large, and a prominent posterior style appears at the postero-external angle of the crown, an element which is rarely found in either p_2 or p_3 of the permanent series. The third milk-premolar is larger than dp_2 especially in transverse width, and differs from its permanent successor chiefly in the presence of a very conspicuous posterior and a smaller anterior style on the external face. The fourth milk-premolar is more completely molariform than p_4 , in having two well-defined internal cusps

(deutero- and tetartocones), but the external median rib, or style, is less prominent than in the true molars.

B. Lower Jaw. The lower milk-teeth are more closely set than the corresponding permanent ones and the first six form an imbricating series, the hinder edge of each tooth overlapping the one behind it; these teeth all increase in size and complexity toward the posterior end of the series. The milk-incisors and canines are lower, but relatively much more extended antero-posteriorly than their permanent successors; each has on its internal face a low, median, vertical ridge, which becomes more prominent on each succeeding tooth and is most conspicuous on dp_1 and 2 .

Lydekker ('93, 68) states that in the mandible of young individuals of *T. lydekkeri* the alveoli of the incisors are directed forward almost horizontally. I am quite at a loss to understand this statement, for I have seen nothing in the milk or permanent dentition which could justify, or even suggest, such a description. On the contrary, in all of the individuals examined by me the incisors, whether temporary or permanent, are quite erect and show no tendency to become procumbent, and Ameghino ('94b, 283) reports the same conclusion. I can only suppose that Mr. Lydekker has had before him a specimen deformed by crushing, or possibly an abnormal individual.

All of the milk-premolars are implanted by two roots; the third is imperfectly molariform, having two crescents and, in addition to the pillar on the inner side of the posterior crescent which the molars also have, there is a similar, though smaller, pillar in the concavity of the anterior crescent. The fourth milk-premolar is indistinguishable from one of the permanent molars, except for the presence of the pillar in the anterior crescent.

The specimens at my disposal show little regarding the manner in which the teeth succeed one another. The first molar in both jaws is in function before any of the milk-teeth have been shed; the second molar is in process of eruption at the same time and was probably in use before any of the second series. In one individual with milk-dentition still complete, the fully formed, but as yet rootless, crown of p^4 is nearly ready to displace dp^4 , and it therefore seems likely that that tooth is the first of the second series to erupt.

If we compare with the dentition of *Theosodon* that of *Macrauchenia patachonica*, from the upper Pampean beds, the latest and most specialized member of the family, we observe that the changes are surprisingly

few and small in amount. In *M. patachonica*, the upper incisors are no longer arranged in an antero-posterior line, but form a transverse series, and have become relatively smaller and more chisel-shaped. In both jaws, the incisors have an enamel pit, or "mark," somewhat resembling that of the horses, and formed by the great growth of the internal cingulum, which is in a merely incipient stage in *Theosodon*. Bravard's figures (Burmeister, '64, Pl. I, figs. 2, 3) appear to show that the upper canine was two-rooted. The premolars are little or not at all more complex than in *Theosodon*. The upper molars are not quite so strictly brachyodont as in the Santa Cruz genus; the external crescents are more angular and more deeply concave, and the grinding surface is somewhat more complicated, with three or more enamel lakes in the moderately worn stage, but the change from *Theosodon* is not great. The lower molars are simplified by the suppression of the pillar in the posterior crescent, but Ameghino states that it is present in the milk-teeth ('94*b*, 279).

Skull (Pl. XVII, figs. 1, 1*a*, 1*b*).—The skull of *Theosodon* is extremely interesting and peculiar and differs much more from that of *Macrauchenia* than would be expected from a comparison of the teeth alone. As in all the other known genera of this family, the skull of *Theosodon* is long, narrow and low, but the dorso-ventral shallowness is, in most specimens, exaggerated by the vertical crushing and distortion to which the skull has been subjected. It is rare to find an individual which has suffered neither lateral nor vertical distortion. Both cranium and face are elongate, the anterior margin of the orbit, which is above the middle of m^2 , forming nearly the median point in the total length of the skull. The upper profile of the skull rises but little from the occipital crest to the parietal eminence and thence descends very slightly and gradually to the end of the nasals, from which point it slopes down very rapidly to the low rostrum. In *Macrauchenia*, the parietal eminence is higher and farther forward and from it the upper profile descends in an almost uninterrupted slope to the end of the rostrum, the minute, vestigial nasals forming the only break in the line.

The occiput is quite high and narrow, broadest at the base and rapidly contracting dorsally; above the foramen magnum, the surface is strongly convex transversely; the foramen itself is quite large and of nearly circular shape. The occipital crest is low and thin and passes uninterruptedly into the dorsal border of the zygomatic process of the squamosal, thus completely defining the temporal fossa behind.

All the available specimens are either of such old individuals, or have suffered so much from crushing, that it is exceedingly difficult to make out the various bones of the skull, and some I have not been able to determine at all. The basioccipital is moderately elongate, broad and with a ventral keel, the prominence of which varies in different individuals, becoming higher with age: on each side of the bone is a conspicuous pit, or rugosity, for the attachment of the *rectus capitis* muscle. Even in very young skulls, the basi- and exoccipitals are indistinguishably fused together, without any trace of a suture. The exoccipitals are low, broad, extremely thick and massive, and so dense that the cancellous structure is not immediately obvious; the paroccipital processes are very conspicuous and of moderate length, descending below the level of the condyles, and are broad and antero-posteriorly compressed, with convex anterior, and concave posterior surface. The condyles are quite large and the articular surface of each is prolonged forward upon the basioccipital in much the same way as in *Macrauchenia*. Large condylar foramina perforate the basioccipital laterally and are entirely concealed by the overhanging condyles, when the skull is viewed from below. The supraoccipital is a small, but very thick and heavy bone, massive and dense and without a sinus.

The basisphenoid is broad and heavy, contracting forward. The limits of the ali- and orbitosphenoids in the cranial wall cannot be definitely made out in any of the specimens at my disposal. The parietals are very large and form the greater part of the brain-case, which is narrow and of no great capacity. Anteriorly, the parietals are deeply emarginated in the median line, to receive the broad posterior processes of the frontals. The sagittal crest is broad anteriorly, contracting posteriorly to a thin ridge, the length and height of which are variable, though in general they may be said to increase with age. There are also marked specific differences in the development of the sagittal crest, as, for example, between *T. lallemanti* and *T. garrettorum*.

The squamosal is long and low, not rising much upon the side of the cranium, most of which is formed by the parietal; the posttympanic process is short and inconspicuous and is closely applied to the mastoid. The zygomatic process is quite long, extending forward to form a small portion of the lower margin of the orbit, but has no trace of a postorbital process; it is slender and laterally compressed, and arches out but little from the side of the cranium; the proximal portion, or root, of the process is much

extended antero-posteriorly, forming a broad shelf. The glenoid cavity is a large, almost circular depression, concave in both directions. The post-glenoid process is rather short, but broad and heavy.

The tympanic is very loosely attached to the skull and, in most cases, has been lost; it is very small and can hardly be said to form a bulla at all, being little more than a flat, scale-like bone, with a large, irregular auditory meatus, which is a mere hole and has no tubular prolongation. The large periotic, which is concealed by the tympanic, is very dense and antero-posteriorly elongated, laterally compressed, with convex external, and nearly flat mesial surface. A small triangular area of the mastoid portion is exposed on the surface of the cranium between the exoccipital and squamosal.

The jugal is long, slender and laterally compressed; posteriorly, it extends almost to the glenoid cavity, and anteriorly, it articulates with the lachrymal, thus forming nearly the whole lower margin of the orbit. As a whole, the zygomatic arch is thin and weak, but relatively considerably longer than in *Macrauchenia* and the temporal opening is correspondingly elongate, though actually quite small. It is true that Ameghino's figure ('94a, 29, fig. 6) appears to show very long temporal openings, but, in all probability, this is merely an appearance, due to the fact that the matrix has not been removed from the root of the zygomatic processes. As is shown in Plate XVII, fig. 1b, the root of this process is much extended antero-posteriorly, reducing the size of the temporal opening. The lachrymal is rather small, and has but a moderate facial expansion; the foramen is single and is placed on the margin of the orbit, and the lachrymal spine is a low tubercle.

The frontals are very large, especially in transverse width, and form a broad forehead, which, in undistorted specimens, is strongly convex transversely and indicates the presence of large frontal sinuses. The postorbital processes are long and slender, with rugose margins and so curved as to be concave anteriorly and convex posteriorly; they do not quite reach the jugals and thus leave the orbits partly open behind. The supraorbital margin is rough and tuberculated and is perforated by a large foramen, which opens downward into the orbit, and, in addition, there is on each side a large vascular opening, nearly midway between the sagittal suture and the orbital margin. Anteriorly, the frontals send forward between the nasals a pair of median processes, the size of which varies much in the

different species. In *T. garrettorum* these processes are broad and conspicuous and widely separate the nasals, while in *T. lallemanti* (*lydekkeri*), as figured by Ameghino (*loc. cit.*), they are very much reduced.

The surface of the frontals is quite smooth and there is no indication of the deep median depression, with pits and ridges for the insertion of the muscles of the proboscis, which is so very conspicuous a feature in the skull of *Macrauchenia*.

The nasals are greatly reduced and very short, though much larger than the vestigial remnants seen in the Pampean genus; they are strongly curved transversely and almost semicylindrical, with dorsal and lateral faces. According to Ameghino's figure (*loc. cit.*), in *T. lallemanti*, the nasal processes of the frontals are short and narrow and the nasals themselves are in contact for nearly their entire length. In *T. garrettorum*, on the contrary, the very large processes so separate the nasals, that they do not touch each other at any point. The great shortening of the nasals is an indication that some sort of a proboscis, or prehensile upper lip, must have been present in the living animal, while the absence of any special area for muscular attachments shows that the proboscis cannot have attained any such development as it had in *Macrauchenia*. The anterior narial opening is very long and narrow, differing much in shape and position from that seen in the Pampean genus. As a whole, the opening is much more anterior in position than in the latter and extends forward between the maxillaries for their entire length and even slightly invades the premaxillaries, and posteriorly, it terminates in front of the orbits, which themselves occupy a more anterior position than in *Macrauchenia*.

The maxillaries are very elongate and immediately in front of the orbits, where they articulate with the nasals, they have considerable dorso-ventral height, but from the end of the nasal suture this height diminishes rapidly and the anterior portion of the maxillaries is very low. Except in the palatal region, the two maxillaries are nowhere in contact, being separated for their entire length by the anterior nares. The infra-orbital canal, which is rather small, opens above m^1 . The premaxillaries are relatively elongate and very low dorso-ventrally, and are not distinguished into alveolar and ascending rami. They are broad, depressed and flattened, slightly convex on the dorsal surface and overlapping the maxillaries behind. For most of their length, the two bones are in contact,

diverging somewhat posteriorly and enclosing the front end of the narial opening. Even in the oldest individuals, they display no tendency to coössify.

The bones of the hard palate are exceedingly thin and fragile and in none of the specimens at my disposal are they in a satisfactory state of preservation. Apparently, there are no incisive foramina, but merely grooves in the position occupied normally by those foramina. In *T. gracilis* Ameghino ('94b, 32, fig. 9) figures very long, narrow foramina, separated by a slender spine, but it seems likely that, in this instance, the draughtsman was deceived by grooves filled with matrix. Lydekker's figure ('93, XXVI, 2) would appear to be open to either interpretation. If, however, no error be involved in Ameghino's figure, the presence of the incisive foramina would sharply distinguish *T. gracilis* from the other species. The maxillary part of the palate is of nearly uniform width between the two parallel rows of teeth, broadening slightly in the anterior premolar region. Shallow grooves run near the outer margins of the maxillary palatine processes for nearly their entire length. At the anterior end of these processes, as may be seen in Plate XVII, fig. 1a, is a median opening, continuing forward as the premaxillary grooves already mentioned. Probably this opening served to transmit the blood-vessels and nerves which ordinarily pass through the incisive foramina, but so distorted is this region in even the best-preserved skulls, that I cannot feel entirely confident of this interpretation.

The palatines very early coalesce with the maxillaries and, even in young animals retaining all of the milk-teeth, their limits are difficult of determination. Apparently, however, they form a moderate portion of the hard palate, with antero-posterior extent about equal to that of a molar tooth; the posterior palatine foramina, so far as can be judged from the imperfect material, are entirely within the limits of the maxillaries. The posterior nares are long, narrow and low, with nearly parallel walls; the front border is on a line with the middle of m^2 , while posteriorly the walls arise opposite the middle of the glenoid cavities. The pterygoids terminate in low, inconspicuous hamular processes, and the fossæ are mere grooves. The vomer is strongly developed and divides the forward part of the posterior nares into two openings.

Like so many other features of these more or less crushed and distorted skulls, the *cranial foramina* are difficult to determine satisfactorily. So

far as they can be made out, they differ in no important respect from those of the other Santa Cruz family of the Litopterna, the Proterotheriidæ. The optic foramen is a large opening, situated low down upon the side of the cranium and behind the orbit. Below and a little behind the optic foramen, is the foramen lacerum anterius, also a large opening, especially in the dorso-ventral diameter, but quite narrow and slit-like transversely. There is no alisphenoid canal, and the foramina rotundum and ovale appear to be confluent, a single large aperture perforating the alisphenoid internal to the glenoid cavity. A large, irregular opening in front of the tympanic doubtless includes both the eustachian canal and the foramen lacerum medium. The foramen lacerum posterius is much smaller and no carotid canal is discoverable. The postglenoid and stylo-mastoid foramina are deep-set, but large and conspicuous. As already mentioned, the condylar foramina perforate the basioccipital in a horizontal direction and are concealed, in ventral view, by the overhanging condyles.

In the adult animal, the two halves of the lower jaw are indistinguishably fused together at the symphysis, a coalescence which takes place at quite an early period. The horizontal ramus is very low and shallow dorso-ventrally, but quite thick and stout transversely; the ascending ramus is broad, but, aside from the coronoid, is not very high and the condyle is raised but moderately above the level of the teeth. The angle projects much posteriorly, and its free border is rounded and somewhat incurved; the masseteric fossa is large but very obscurely defined. The condyle, which is almost sessile, is moderately convex; on the hinder face of the internal half is an articular surface for the postglenoid process of the squamosal. The sigmoid notch is very narrow and the coronoid process is very high, slender and somewhat recurved; in the very young animal the shape of the coronoid suggests that of the camel. The lineæ obliquæ are very prominent and enclose quite a deep fossa, or depression, behind the last molar. The inferior dental foramen is very large and there are usually three mental foramina, beneath the canine and the first and second premolars respectively.

Of the hyoid apparatus (Pl. XVII, figs. 1*a*, 2), two elements are preserved; one is the relatively long, slender, cylindrical and outwardly curved tympanohyal, which is not attached to the very small tympanic bone, but to the posttympanic process of the squamosal. The other element is the stylohyal (fig. 2), which has some resemblance to that of

the horse; this is long, slender, much compressed laterally and tapering distally; the proximal end is expanded in the antero-posterior direction, forming a large, thin, bony plate. Though chiefly posterior, this expansion is less exclusively so than in the horse.

The skull of *Macrauchenia patachonica* is manifestly of the same type as that of *Theosodon*, but has undergone extensive modifications, chiefly in response to the development of the proboscis. The face has become relatively more elongate, owing to the shifting of the orbits, which are now behind the dental series and are completely encircled in bone. In correlation with this shifting of the orbits, the zygomatic arches are shortened and the temporal openings reduced in size. The cranium is shorter and more rounded and the sagittal crest is replaced by a broad sagittal area. The premaxillæ are shorter and broader and are thoroughly fused together in the median line, as are also the maxillaries for the greater part of their length, thus forming a long, solid rostrum. The anterior narial opening is greatly reduced in length and shifted backward between the orbits and vertically above the posterior nares. Behind the superior narial opening, there is a deep depression of the frontals, at the bottom of which are conspicuous pits and ridges for the attachment of the muscles of the proboscis.

As Ameghino has demonstrated ('94*b*, 277 ff.) several genera of the family, of intermediate geological dates, form a series of gradations in dentition and skull structure between *Theosodon* and *Macrauchenia*. Of these the most important are *Mesorhinus* and *Scalabrinitherium*. The former, unfortunately still very incompletely known, has the premaxillaries ankylosed and part of the maxillaries also; behind this symphysis is a groove, which widens and deepens posteriorly and leads back to the anterior nasal opening, which begins much farther back than in *Theosodon* and not so far as in *Scalabrinitherium*. In the latter genus the approximation to *Macrauchenia* is still more marked; the orbits have shifted backward, bringing the anterior rim over m^3 ; the nasals are much reduced, though still considerably longer than in the Pampean genus. The anterior nares have been displaced backward, though not so far as in *Macrauchenia*, and there is as yet no depression of the frontals for muscular attachments. The upper molars have a somewhat more complex pattern than in *Theosodon*, a change which principally consists in the deepening of the external crescents and in the development of the antero-internal cingulum into a more independent crest.

Vertebral Column, Ribs and Sternum. — In one individual, the type of *T. garrettorum* (No. 15,164) the vertebral column appears to be complete to the end of the sacrum and gives the formula: C.7, Th.13, L.6, S.7. This is a surprise in view of the widely held opinion that *Macrauchenia* had the perissodactyl formula of 23 trunk-vertebræ, and, at first sight, this would seem to militate strongly against the derivation of the Pampean genus from *Theosodon*. It is, however, very doubtful whether *Macrauchenia* actually possessed so large a number of trunk-vertebræ. Burmeister, it is true, definitely states ('91, 483) that in the La Plata Museum skeleton the number of thoracic vertebræ is 18 and of lumbar vertebræ 5, but there is some inexplicable mistake involved in the statement, as the La Plata skeleton is much less complete than Burmeister seems to have supposed. In fact, that skeleton, which Lydekker has figured ('96, 76, fig. 10) makes it very probable that the number of trunk-vertebræ could not have exceeded 19 or 20. On the other hand, it is not altogether certain that the number 19 attributed to *Theosodon* is correct, for the specimen above referred to (No. 15,164) was not found with all the bones in their natural connections and it is possible that some of the vertebræ are missing. Still, the vertebræ, when put together, seem to form a complete series without breaks.

In *Theosodon* the neck is very long and its proportions have much resemblance to those seen in the llama. The atlas (Pl. XVIII, fig. 2) is quite elongate in proportion to its width, though very much shorter than the succeeding cervicals, and has a large, subcircular neural canal. The anterior cotyles for the occipital condyles are large, widely separated dorsally, where the neural arch is quite deeply emarginated between them; ventrally, the cotyles are much more closely approximated. The posterior cotyles for the axis are small and nearly plane, while the facet for the odontoid is quite deeply concave transversely and is not confluent with the posterior cotyles. The neural arch is broad in both directions and moderately curved; the spine is a very low ridge, the height of which varies somewhat in different individuals. The inferior arch is quite narrow antero-posteriorly and has but a very small hypapophysis, or none at all. The transverse processes are very short, with regularly curved free border; anteriorly, they do not reach the outer wall of the cotyles but are notched and posteriorly, the cotyles also project behind them. At the base, the transverse processes are perforated by the vertebrarterial canal,

the posterior opening of which is small, while the anterior opening is much larger. The only other foramina present are those in the neural arch for the spinal nerves.

Compared with the atlas of *Theosodon*, that of *Macrauchenia* shows the following differences: (1) As a whole, the atlas of the Pampean genus is shorter, broader and more depressed, and the neural canal is much smaller, while the neural spine and hypapophysis are much better developed. (2) The anterior cotyles are more closely approximated, both dorsally and ventrally, and their mesial ventral portions emarginate the inferior arch in a characteristic way, not seen in *Theosodon*. (3) The transverse processes are much longer, thicker dorso-ventrally, and decidedly recurved, projecting behind the posterior cotyles; anteriorly, the processes extend the full length of the atlas, converting the atlanteo-diapophysial notches into foramina for the inferior branches of the spinal nerves. (4) The transverse processes are not perforated by the canals for the vertebral arteries.

The axis (Pl. XVIII, figs. 3, 3a) is extremely elongate. Anteriorly, the centrum is much broadened by the articular surfaces for the atlas, which are slightly convex in both directions and are somewhat inclined, sloping dorsally and backward, so that when the atlas and axis are put together, the two bones form a distinct angle. Dorso-ventrally, the diameter of the cotyles is greater than transversely. Deep sulci separate the cotyles from the odontoid and, internal to each one, is a conspicuous vascular foramen. The odontoid process is moderately elongate, peg-like and somewhat depressed, with a facet for the atlas on the ventral side.

It is very exceptional to find an ungulate animal with very long neck, in which the odontoid process retains its primitive, peg-like shape. In all other known instances, except the present family, the long neck is associated with a spout-shape of the odontoid, and in many groups, such as the horses and camels, the transformation of the odontoid keeps pace with the elongation of the neck. This is another example of the curiously primitive features which, in the Litopterna, so frequently persist despite a high degree of specialization.

The centrum of the axis narrows much to the middle, expanding again to the posterior face, which is decidedly opisthocœlous. On the ventral side of the centrum is a keel, which divides posteriorly into two quite prominent ridges. The neural arch is high and narrow in front, wider behind; the spine is long antero-posteriorly, rather low and plate-like,

projecting anteriorly over the base of the odontoid and terminating behind in a stout rod, which extends well behind the postzygapophyses. The latter structures are narrow, but project far behind the centrum, so that they are visible for their full extent when the vertebra is viewed from the ventral side. The transverse processes are short, slender and imperforate. The anterior opening of the vertebralarterial canal is large and pierces the base of the neural arch in front of the transverse process. From this point the canal runs diagonally upward and backward through the side of the neural arch and opens posteriorly into the neural canal.

In *Macrauchenia* the axis differs from that of *Theosodon* in the following respects: (1) The centrum is broader and less constricted in the middle. (2) The odontoid process is shorter. (3) The neural spine is higher dorso-ventrally and projects farther in front, not so far behind. (4) The anterior opening of the canal for the vertebral artery is smaller and placed higher up on the pedicel of the neural arch.

The third cervical is very long and has a centrum which, aside from the anterior cotyles, is very like that of the axis, with a constriction in the middle and broad, depressed faces; the ventral keel, as in the axis, divides posteriorly into two divergent ridges. The neural canal is small and the zygapophyses are long and narrow, projecting well in front of and behind the centrum. The neural spine is a long ridge, with straight and nearly horizontal border; anteriorly, the spine is quite high, posteriorly, the neural arch rises so as to reduce the height of the spine, which dies away upon the arch in front of the postzygapophyses. The anterior opening of the vertebralarterial canal is at the base of the pedicel of the neural arch, the remainder of the canal being concealed within the arch. The transverse processes are short, but much extended in the antero-posterior direction; each is divided into two portions, a smaller anterior part, which projects in front of the centrum, and a larger posterior part. Both parts have a horizontal direction and lie in nearly the same fore-and-aft plane.

The fourth cervical differs from the third in several respects. The centrum is less depressed and its faces have more nearly equal transverse and dorso-ventral diameters. The neural spine is much less extended antero-posteriorly, but nothing can be determined as to its height, since it is broken in all of the available specimens; the zygapophyses are somewhat larger and the canal for the vertebral artery has a similar position. On the other hand, the transverse processes are quite different; the ante-

rior portion is bent downward, making the broad side present laterally, somewhat as in the camel. This anterior portion is connected with the centrum by a comparatively narrow neck and becomes much broader antero-posteriorly on the ventral side. The hinder portion of the process is much more extended from before backward than the forward portion, is horizontal in direction and has a more elevated position, arising from the centrum a little below the base of the neural arch.

In *Macrauchenia*, this vertebra has a broader, heavier and more depressed centrum than in *Theosodon*, with faintly marked ventral keel, which does not divide into divergent ridges. The anterior portion of the transverse process is shorter from before backward, not projecting so far in front of the centrum, has a much more thickened and rugose free border, and is not constricted at the junction with the centrum.

In *Theosodon*, the fifth cervical (Pl. XVIII, figs. 4, 4a) differs so little from the fourth as hardly to require a separate description. It is large and heavy, has a neural spine which is low and shorter from before backward and the anterior portion of the transverse process joins the centrum by its full breadth, without constriction.

The sixth cervical is much shorter than any of the preceding vertebræ, except the atlas, and the centrum is so curved that the ventral face is concave antero-posteriorly, and has a very low and thin, but very distinct median keel. The broad neural arch encloses quite a large neural canal, and the spine has a forward inclination. The transverse processes are, as usual in the Mammalia, divided into diapophysial and pleurapophysial elements; the former is a short, broad plate, extending horizontally outward from the sides of the centrum, with thick and rugose free border, and, as in mammals generally, is perforated by the canal for the vertebral artery. The pleurapophysis, or inferior lamella, is very large and prominent, extends along the whole length of the centrum and is directed almost downward, with thickened ventral border.

In *Macrauchenia*, this vertebra is of a similar type to that just described, but differs in a number of details. (1) The centrum is considerably shorter in proportion to the length of the fourth cervical, as well as broader and more depressed. (2) The neural canal is smaller and the zygapophyses, especially the posterior pair, are much more strongly divergent from each other. (3) The diapophysis is thicker dorso-ventrally and is not perforated by the vertebrarterial canal, while the inferior lamella is less prominent

and less vertical, having a more outward inclination, so that, when seen from below, the lamellæ of the two sides are more divergent.

The seventh cervical of *Theosodon* is much shorter than the sixth and has a broader and more depressed centrum, especially behind, where the width is increased by the large rib-facets; the ventral keel is quite prominent and much thicker than on the sixth vertebra, with a rough tubercle at the anterior end. On the dorsal side of the centrum, forming the floor of the neural canal, is a wedge-shaped prominence from each end, with a depression on each side of it; the two wedges do not meet in the middle of the centrum and the concavities are connected between the apices of the wedges. The neural canal is large, but the neural arch is quite narrow and slender, being greatly reduced by the deep notches between each pair of zygapophyses, which are more widely separated and the posterior pair more strongly divergent than in any of the other cervicals. The transverse processes are quite broad and depressed; their full length is not shown in any of the specimens, but was probably not great. A minute canal pierces the base of the transverse process and may have transmitted a branch of the vertebral artery, but is far too small to have contained the main trunk of that artery.

The number of trunk-vertebræ is not as yet determined beyond all question, but, as we have already seen, was very probably 19, and their division into regions varies slightly, as it does in existing mammals; the thoracic vertebræ may be either 13 or 14, and the lumbar 6 or 5.

Curiously enough, the first thoracic vertebra (Pls. XVII, fig. 5; XVIII, 6) is remarkably like a cervical in appearance, and especially the seventh of that series, from which it differs principally in the presence of an additional pair of facets for the heads of the second ribs and of facets for the tubercles of the first pair on the transverse processes. So, there can be no question as to the place of this exceptional vertebra in the series. The centrum is shorter than that of the last cervical, with narrow anterior and broader posterior face, and much less distinct ventral keel. On the dorsal side of the centrum are wedge-shaped prominences which are like those of the seventh vertebra, but are more nearly in contact at their apices. The anterior rib-facets are very large, the posterior smaller and more concave. The neural canal is large and the arch narrow, though broader than that of the last cervical. Although the neural spine is broken in all of the specimens, it obviously was short and slender and had a decided

forward inclination, in very marked contrast to the spines of the succeeding vertebræ. The zygapophyses are of altogether cervical type, but those of the posterior pair are less strongly divergent than in the seventh cervical. The transverse processes also are very much as in the latter vertebra, but are not quite so broad antero-posteriorly and are thicker dorso-ventrally, especially at the distal end, where they are very heavy and rugose. On the ventral side of each process is an oval, concave facet for the tubercle of the first rib.

Functionally, the first thoracic is, to a certain extent, a part of the very elongate neck, not so much adding to its length, as increasing its flexibility and ease of movement.

The second thoracic resembles the first of most ungulates. The centrum is of a shape similar to that of the preceding vertebra, but is smaller, and the wedge-shaped prominences on the dorsal side have coalesced into a low, rounded ridge; the facets for the rib-heads are very large and the anterior and posterior pairs are quite closely approximated. The transverse processes are short and heavy, with facets for the rib-tubercles which are more obliquely lateral than in the first thoracic. The prezygapophyses are of the cervical pattern, while the postzygapophyses have the thoracic character and are placed on the ventral side of the overhanging neural arch. The spine, though incompletely preserved, was evidently higher and heavier than that of the first thoracic, shorter and more slender than in the succeeding vertebræ, and has a moderate backward inclination.

The following vertebræ of the anterior thoracic region (Pl. XVIII, fig. 5) have short, wide, somewhat depressed and opisthocœlous centra, growing more compressed and triangular and having flatter faces posteriorly; the anterior rib-facets are very elongate, but narrow, while the posterior pair are rounder and more deeply concave. The transverse processes are short, but heavy and conspicuous, with prominent metapophyses arising from the dorsal border, and have subcircular, slightly concave facets for the rib-tubercles. The neural canal is small and nearly circular and the pedicels of the neural arch are deeply notched for the passage of the spinal nerves. The neural spines are very high, laterally compressed and broad, so that those of several successive vertebræ are in contact for their whole length, and have a strong backward inclination or even a backward curvature.

In the anterior thoracic region, the vertebræ closely resemble the cor-

responding ones of *Macrauchenia*, figured by Burmeister ('64, Pl. II, fig. 17), but in the Pampean genus the metapophyses are not so prominent, while the neural spines are narrower, thicker and more recurved.

In the middle of the thoracic region, in *Theosodon*, the neural spines become narrow, more spaced apart and lower, though retaining their backward inclination through nearly the entire region. In the hinder part, the spines become shorter, broader and more erect; the anticlinal vertebra may be either the last or the penultimate thoracic. The transverse processes remain prominent throughout the series, gradually descending from the neural arch to the centrum. The facet for the rib-tubercle persists even on the last vertebra, in which the process has a different form, being broader and more depressed. Between the tenth and eleventh thoracic vertebræ, takes place the transformation of the zygapophyses from the thoracic to the lumbar type. On the tenth, the prezygapophyses still present upward and are small and nearly flat, but the metapophyses, which are now close to them, are strongly concave on the mesial side and curve around the postzygapophyses of the ninth, though not actually articulating with them. The postzygapophyses of the tenth are convex and semicylindrical and the prezygapophyses of the eleventh are concave.

The lumbar vertebræ (Pl. XVIII, fig. 7) are sometimes five and sometimes six in number. Except the last one, they have centra which are laterally compressed and of subtriangular shape, much like those of the thoracic vertebræ, but larger, instead of the broad, depressed centra, usual in the lumbar region. The last lumbar vertebra has a short, depressed centrum, with broad anterior, very narrow and convex posterior face. As in all of the known Santa Cruz Litopterna, the zygapophyses are of the semicylindrical, interlocking character, most resembling those of the *Artiodactyla*. Metapophyses are present throughout, but are less prominent than in the thoracic region and are very small on the penultimate lumbar. The neural spines are high, broad and strongly curved forward and, except in the first and second lumbar, they have not the abruptly truncated and thickened free ends which occur in the lumbar region of nearly all mammals, but are gently rounded. On the last vertebra, the spine is decidedly smaller than on any of the preceding lumbar.

The transverse processes are broad and curved forward; this breadth increases posteriorly, reaching a maximum on the last vertebra. On the hinder border of each transverse process of the penultimate lumbar and

the anterior border of the last, is a large oval facet, by means of which the processes of the two vertebræ articulate. The last lumbar is further characterized by the extremely large and deeply concave oval facets, much larger than the posterior face of the centrum, on the hinder border of the transverse processes, for articulation with corresponding surfaces on the sacrum.

The sacrum (Pl. XVIII, figs. 8, 8*a*) is long and narrow and may consist of seven vertebræ, only two of which articulate with the ilia. Even the first sacral vertebra has but a small and much depressed centrum and on each side of it, on the pleurapophysis, is a large, convex, oval boss, for articulation with the transverse process of the last lumbar, as above described. On the first sacral, the pleurapophyses are large and massive, making this region of the sacrum very wide; those of the second vertebra are much smaller. Posteriorly, the coalesced centra grow smaller and smaller and that of the last vertebra is very small indeed. The first two pairs of ventral foramina for the nerves are very large, the third pair are of moderate size and the succeeding ones are minute. Functional prezygapophyses are present on the first sacral and very small vestigial remnants on the second; behind this, not even vestiges remain. The neural canal is remarkably small, even anteriorly, diminishing in size posteriorly, and the hinder aperture is a mere narrow slit. The coalesced neural arches are deeply concave transversely, owing to the elevation of the lateral borders into high ridges.

No caudal vertebræ have yet been found, but it is evident from the character of the sacrum and the greatly reduced size of the hindermost centrum, that the tail must have been very short.

The first rib is short and nearly straight, with large head set upon a prominent neck, and very conspicuous tubercle; the shaft is slender proximally, broadening and flattening toward the distal end. Speaking generally, it may be said that the anterior ribs have large heads and tubercles, and long, broad and curved shafts; while posteriorly they become more slender and rod-like. Separate tubercles are present throughout, even on the last rib.

The sternum (Pl. XVIII, fig. 9), which is not completely preserved in any of the specimens, is very peculiar. The presternum is long, laterally compressed, and keel-like, with broader dorsal, and very thin ventral border, and increasing in dorso-ventral depth posteriorly; near the anterior

end are facets for the first pair of ribs. This is succeeded by a number of mesosternal segments (how many, it is not yet definitely known) which are shorter and somewhat broader, but very deep dorso-ventrally and laterally compressed. Next follows the complex shown in the figure. Of this, the first segment is compressed and deep anteriorly, becoming broad and dorso-ventrally depressed behind. The last segment of the mesosternum is wide and flat, and somewhat constricted in front of the posterior expansion, which bears facets for three pairs of ribs. The xiphisternum, which, in the adult animal, is ankylosed with the last mesosternal segment, is quite narrow and appears to have been short.

The Appendicular Skeleton.—The scapula (Pl. XIX, figs. 1, 1a) is high and rather narrow and, in its general proportions, recalls that of the rhinocerotid genus *Hyracodon* from the North American Oligocene. The position of the spine is slightly back of the median line of the blade, and thus makes the prescapular fossa a little larger than the postscapular; the former has an irregular surface of low convexities and shallow concavities, while the latter is more simply concave. The glenoid cavity is large and concave in both dimensions and of subcircular outline, except anteriorly, where the articular surface extends over upon the coracoid and is much narrower.

The coracoid is a prominent, rounded and somewhat rugose boss, which is not incurved and does not overhang internally. The neck of the scapula is short and wide, and there is no definite coraco-scapular notch. The coracoid border is somewhat sinuous; after a short course upward and forward from the neck, it becomes nearly straight for a considerable distance and curves, without angulation, into the suprascapular border. The latter is quite strongly convex and joins the glenoid border by a rounded angle. The glenoid border is nearly straight and inclines downward and forward till just above the neck, where it forms a concave curve. For most of its length, this border is elevated as a ridge and in the distal half of its course this ridge divides into two, both ridges dying away to the neck. Beginning some distance below the suprascapular border, the spine rises very gently to its full height and pursues a somewhat twisted course, the proximal half being deeply concave behind, and the distal half more nearly perpendicular to the blade. About midway of its length, the spine gives off a very large triangular, and rugose metacromion. The acromion proper is also very large and round, projecting strongly back-

ward, but not at all distally, the distal border of the spine being nearly straight and normal to the plane of the blade.

The fore-limb is long and slender and its three divisions are proportioned somewhat as in *Hyracodon*, the cursorial rhinoceros from the Oligocene of North America. That is to say, the upper arm is very short, the fore-arm is greatly, and the manus moderately elongate.

As just indicated, the humerus (Pl. XVIII, fig. 10; Pl. XIX, fig. 5) is relatively short and stout, hardly more than two-thirds the length of the skull. The head is large and rather flattened and projects backward but little; the external tuberosity is very largely developed, as a high, massive ridge, which rises far above the level of the head, while the internal tuberosity is very much smaller and less prominent. The bicipital groove, which is single and without any tubercle, is wide and deep; the deltoid crest is prominent and rugose and extends down for nearly half the length of the shaft, ending abruptly below. The shaft is proportionately quite massive and of the usual ungulate form. Proximally, the shaft is much compressed laterally and very thick antero-posteriorly, though this latter dimension is not so exaggerated as in *Macrauchenia*. Distally, the shaft becomes wider transversely and thinner antero-posteriorly; the epicondyles are massive and the external one is quite prominent; there is no entepicondylar foramen. The supratrochlear fossa is well-marked and the anconeal fossa is large, of irregular shape and deep, but the two fossæ are not connected by a perforation. The trochlea, which is placed somewhat obliquely to the long axis of the shaft, rising toward the inner side, is extremely simple and forms a pulley-shaped surface not unlike the astragalar trochlea of a rhinoceros. Of the two borders, the internal is the sharper and more elevated; posteriorly, the groove for articulation with the ulna is very deep. The articular surface is continuous throughout and shows no indication of a division into facets and there is no median trochlear ridge.

The bones of the fore-arm (Pl. XIX, fig. 2) are long and slender and, though without any tendency to coössification, they are in close contact throughout their length and there is no radio-cubital arcade. Proximally, the ulna is much stouter than the radius; distally, the radius is the heavier of the two.

The radius (Pl. XIX, figs. 2, 3, 3a) is elongate and very slender. Indeed, in view of the tridactyl and mesaxonitic manus, the enlargement of

the radius and reduction of the ulna are remarkably small, when compared with Artiodactyla or Perissodactyla of a similar degree of specialization. The head is very small (see fig. 3a), though its principal diameter is transverse and there can have been no power of rotation upon the humerus. The articular surface for the latter is very simple and slightly concave antero-posteriorly; on the inner side, this surface is sharply bent downward so as to bear laterally against the prominent internal border of the humeral trochlea. The proximal facet for the ulna is curiously small and is confined to a very narrow area on the posterior face of the head near the inner side, and a somewhat longer, narrow area near the outer side. The amount of movement between the two fore-arm bones must have been very limited.

The shaft is long, slender, irregular and with a decided, though not very strong, forward curvature; it is antero-posteriorly compressed and its principal diameter is transverse, broadening distally. The distal end is moderately widened and thickened, so as to be quite massive, and externally, the widening is abrupt, fitting into a corresponding depression of the ulna, the facet for which is a large concavity. No sulci for the extensor tendons are visible on the anterior face. The carpal surface is very distinctly divided into two facets, for the scaphoid and lunar respectively, of which that for the scaphoid is much wider and is reflected farther upward upon the palmar face of the radius, while the lunar facet is deeper palmo-dorsally. Each facet is composed of two parts, a dorsal concavity and a palmar convexity, though the two parts form one uninterrupted surface.

The ulna (Pl. XIX, figs. 2, 4) has a very long olecranon, which projects upward and gently backward, its posterior extension not being nearly so abrupt as in *Macrauchenia*. The sigmoid notch is deep and describes nearly a semicircle. On the inner side of the proximal half of the notch, the articular surface is sharply reflected upward, so as to present laterally, while on the outer side, the surface is broadly divided into two parts. Distally, the facet extends forward beneath the humeral trochlea and appears on the inner side of the head of the radius, when viewed from the front. The proximal facets for the radius are very small, a larger internal, and extremely narrow external one.

The proximal part of the shaft is triangular and very stout, rapidly becoming laterally compressed and very narrow, but remains thick antero-posteriorly and is of nearly uniform cross-section throughout its length.

Above the distal end, the shaft is abruptly contracted, to receive the distal expansion of the radius, and there is a rather large, convex facet for the latter. The surface for the pyramidal is saddle-shaped and has its principal diameter in the dorso-palmar dimension; it is continuous with the small facet for the pisiform, which is quite internal in position.

In *Macrauchenia*, the fore-arm bones are coössified, though not always completely so; they are broader transversely and more compressed antero-posteriorly than in *Theosodon*, even at the distal end. Proximally, the ulna is much heavier than the radius and the relative proportions of the two bones remain very much as they are in the Santa Cruz genus.

The manus of *Theosodon* (Pl. XIX, fig. 6) is surprisingly like that of *Macrauchenia* even in the minor details, as has already been pointed out by Ameghino ('94b, 281). However, a few slight, though not entirely insignificant, changes may be observed in the Pampean genus. The manus is of mesaxonic symmetry and is tridactyl, not only structurally, but functionally, the digits being of nearly equal length and thickness, and each carrying its due proportion of the weight.

The carpus (Pl. XIX, figs. 6, 6a) is low proximo-distally and wide transversely, though relatively somewhat higher and narrower than in *Macrauchenia*. Lydekker's statement ('96, 79) that in the Pampean genus the arrangement of the carpal elements is in vertical series, without interlocking, is not quite accurate. As will be seen, there is a certain degree of interlocking, even in the Santa Cruz genus, and this is increased in *Macrauchenia*.

The scaphoid is low, broad and very thick palmo-dorsally, and of irregularly quadrate outline; the proximal end is covered by the radial facet, which has a dorsal convexity, dying away upon the inner side, and a palmar concavity. On the distal end are three facets; internally, a small concavity for the trapezium, then follows a very large surface for the trapezoid, composed of dorsal and palmar concavities, the junction of which forms a ridge. Finally, there is a heavy distal process, which projects somewhat internally and carries a facet for the magnum and, on the ulnar side, one for the lunar. This extension of the scaphoid over upon the magnum is the only departure from the serial arrangement to be found in this carpus.

The lunar is very narrow, but moderately high proximo-distally, and very thick palmo-dorsally. The radial surface is strongly convex, extend-

ing well down upon the dorsal face, and becoming slightly concave near the palmar side. The facet for the pyramidal is very large and somewhat concave, but is confined to the distal moiety of the ulnar face; proximally, the two bones are quite separate and not in contact (see Pl. XIX, fig. 6a). Distally, the lunar rests only on the magnum and is quite widely separated from the unciform by the interposition of the pyramidal. On this side, the carpus is strictly taxeopod in the arrangement of its elements.

The pyramidal is relatively large and has a greater proximo-distal height than any of the other carpals. Proximally, this bone is rather shallow palmo-dorsally, but becomes very thick in this dimension toward the distal end, and a blunt, rugose process projects from the palmar side. The ulnar facet is very large and saddle-shaped and that for the pisiform, which is also large, presents internally as much as toward the palmar side. On the radial side, near the distal end, is a large surface for the lunar and, distal to this, a narrow facet for articulation with the magnum. This contact is, however, entirely lateral, the pyramidal not overlapping the magnum at all. Here we find a difference from the carpus of *Macrauchenia*, in which the pyramidal extends over upon the magnum and thus forms another departure from the serial arrangement. (See Gervais, '55, Pl. 8, fig. 2.)

The pisiform is short, heavy, of irregular shape and much thickened at the free end, but nearly uniform in the other diameter. The proximal end is also thickened and bears a high, narrow and somewhat saddle-shaped surface for the pyramidal, and on the external side a very small plane facet for the ulna. In *Macrauchenia*, the pisiform is of similar general shape to that of *Theosodon*, but is more compressed laterally, and contracts to form a very much more slender proximal end.

The trapezium is much reduced in size and was of no great functional importance. Proximo-distally, it is elongate, tapering to a bluntly rounded point at the distal end, but the transverse and dorso-palmar diameters are small. The proximal end is a small, simply convex surface for articulation with the scaphoid, while on the ulnar side are two facets, one for the trapezoid and, below this, a much larger concavity for the second metacarpal. The trapezoid I have not seen, though it may be readily reconstructed from the space left vacant between the surrounding bones, which shows it to have been nearly as large as the magnum. This element has been figured by Ameghino ('94b, 282, fig. 18).

The magnum is stout, but not very large, though it has a complete system of articulations, being in contact with the second and third metacarpals and all of the carpals except the trapezium and pisiform. The proximal end is unequally divided between the facets for the scaphoid and lunar, the latter being somewhat wider and more completely proximal, while the former has an oblique position. The "head" of the magnum is quite low and there is no hook given off from the palmar face. On the ulnar side are two nearly plane facets, a proximal one for the pyramidal and a distal one for the unciform. Distally, the entire surface of the magnum is covered by the large, somewhat saddle-shaped facet for the third metacarpal, and on the radial side, near the distal end, is an oblique facet for the second metacarpal, which extends across the whole dorso-palmar diameter of the magnum. Above this is a small surface for articulation with the trapezoid, and this facet is confined to the dorsal moiety of the magnum.

In *Macrauchenia*, as above indicated, the magnum is further modified by its extension under the pyramidal, or the overlapping of the pyramidal upon it. In this way the facet on the magnum for the pyramidal becomes proximal and an interlocking of a very exceptional type is brought about, the magnum lying beneath the scaphoid on one side and beneath the pyramidal on the other, while the lunar is excluded from any contact with the unciform. In all Perissodactyla, on the contrary, interlocking is produced by the growth toward the ulnar side of the scaphoid and lunar, accompanied by the reduction of the pyramidal. Thus the scaphoid rests more or less extensively upon the magnum and the lunar on the unciform, the pyramidal being excluded from the magnum. In the Proboscidea, as in the *Macrauchenidæ*, the magnum articulates with both scaphoid and pyramidal, and, in both groups, this exceptional arrangement is, no doubt, due to the relatively large size of the ulna.

The unciform of *Theosodon* is considerably larger than the magnum; it is low, broad and thick and has a short, massive and rugose process projecting from the palmar face. On the proximal end is a large, saddle-shaped surface for the pyramidal, and on the distal end, an almost equally large facet for the fourth metacarpal, which, however, narrows much toward the palmar side. A very small distal facet indicates the presence of the vestigial fifth metacarpal. On the radial side are two facets, a large one for the magnum and a smaller, oblique one for the third metacarpal.

The metacarpus consists of three functional members, mc. II, III and IV, and a minute remnant of mc. V. In symmetry, the manus is mesaxonic, or perissodactyl, the median plane bisecting the third digit, which is symmetrical, while the lateral digits, II and IV, each asymmetrical in itself, form a symmetrical pair. Functionally, the manus is almost isodactyl, with three subequal digits.

Metacarpal II is elongate and relatively heavy. The head is large and carries four distinct articular facets; on the radial side is quite a large, convex surface for the trapezium and on the proximal end is the large, irregular facet for the trapezoid. On the ulnar side, a prominent, heavy projection abuts against the magnum and overlaps the head of mc. III. This magnum facet is slightly oblique and that for mc. III is in two parts, one presenting distally and the other toward the ulnar side; the latter is a small, oval concavity, placed near the dorsal border. The shaft is stout and heavy, of trihedral section and curved so as to make the radial border concave. The distal trochlea is low and the carina is continued around upon the dorsal face, though it is much more prominent on the palmar side; where the dorsal and palmar portions of the keel meet, there is a distinct notch. On the palmar face, a non-articular ridge extends upward for some distance in continuation of this carina, of which it evidently acted as a support, and gradually dies away upon the shaft.

Metacarpal III is longer, but decidedly more slender than either mc. II or IV. The head is quite heavy and is drawn out into a massive triangular process on the palmar side; the facet for mc. II extends across the whole dorso-palmar diameter of the head and, for most of its length, is obliquely proximal in position, but near the dorsal border it curves downward and presents toward the radial side. The proximal surface for the magnum is large and irregularly saddle-shaped. From the ulnar side is given off a very short projection, which articulates with the unciform, but occupies only the dorsal moiety of the head. On the ulnar side, below the unciform projection, are two facets for mc. IV, which are elongated proximodistally, but very narrow; the one near the dorsal border is quite deeply concave, the other near the palmar border is nearly plane. The shaft is long, narrow, straight and symmetrical, and subquadrate in section, broadening slightly near the distal end. Distally, the semicylindrical trochlea is higher than that of mc. II or IV, but the carina is less prominent on the dorsal face, indeed, is but faintly indicated, while on the pal-

mar side it is extremely prominent and sharp. It is strengthened, as in the other metacarpals, by extending up the palmar side of the shaft into a non-articular ridge.

Metacarpal IV is the counterpart of mc. II, though slightly shorter, not rising so high into the carpus proximally and extending distally a little below the end of mc. II. The head bears a prominent palmar ridge-like process, which, however, is less massive than that of mc. III; the unciform facet is convex and slightly oblique, broad dorsally and narrowing much toward the palmar side. On the radial side of the head are two surfaces for mc. III, that on the dorsal side prominent and convex, that on the palmar side sessile and plane, and on the ulnar side is a small facet for the minute mc. V. The shaft and trochlea resemble those of mc. II reversed.

The vestigial fifth metacarpal has not been found, but its presence may be confidently inferred from the facets on the unciform and mc. IV.

The phalanges of the first row are long and slender and are much alike in all three digits, except that in the median digit this phalanx is shorter than in the laterals, a very unusual proportion in a foot of mesaxonic symmetry, as well as broader and more depressed. In all the phalanges of this row the proximal trochlea is a shallow concavity, deeply divided by the groove for the metacarpal carina. The distal trochlea is simply saddle-shaped, but with the articular surface reflected far over upon the dorsal side.

In the second row the phalanges are short, broad and heavy, with thick proximal and much depressed distal ends. In the median line the dorsal lip of the proximal trochlea is produced into a more or less prominent, beak-like process. The second phalanges of all the digits are of nearly equal length; in the third digit it is slightly longer than in the second or fourth.

The ungual phalanges are short, broad, thick and almost nodular in shape, resembling somewhat those of the slender-footed Oligocene rhinoceroses, but they have lost all vestige of the median cleft. In digit III the ungual is larger than in the laterals, broad and symmetrical, with rugose free border, while those of digits II and IV are quite irregular and asymmetrical.

The pelvis (Pl. XIX, fig. 7) is short and broad and resembles that of *Macrauchenia*, but is less specialized in several particulars. The ilium

has a very short peduncle, which is deep dorso-ventrally, but laterally compressed and thin, and which expands rapidly into the very broad iliac plate. This plate is less strongly everted than in the Pampean genus and the division into dorsal and ventral processes is less distinctly marked. Another difference from *Macrauchenia* is that the ventral process is wider and has a much less thickened border. On the inner side of the dorsal process is a large, rugose depression for the attachment of the sacrum, the process rising well above the latter and concealing it in side-view. On the outer side, the gluteal surface is smooth and but slightly concave. The pubic border of the ilium is very indistinct and speedily dies away upon the inner side. The acetabulum is large and has a very prominent anterior border, and a deep, conspicuous sulcus for the round ligament.

The ischium is quite short and stout, trihedral for most of its length, but expanding posteriorly into a thin plate. The spine and sciatic notch are feebly marked, more distinctly in some individuals than in others, while the tuberosity is very strongly developed, being prominent and rugose, though not nearly so long as in *Macrauchenia*. The pubis is short and heavy, especially in the symphyseal region, the anterior part of which is very thick. As a whole, the symphysis is longer than in the last named genus. On the anterior border of the pubis, near the acetabulum, is the prominent and rugose spine. The obturator foramen is an elongate oval, with its principal axis in the antero-posterior direction, while in *Macrauchenia* it appears to be transverse.

The femur (Pl. XX, figs. 2, 3, 3a) is long and very much like that of *Macrauchenia*, but considerably lighter and more slender. The head is sessile and rather flattened and does not rise to the level of the great trochanter, while in the Pampean type it is large and hemispherical and projects prominently above the trochanter. The sulcus for the round ligament is a broad and deep emargination of the articular surface on the posterior aspect of the head and not visible in front-view. The great trochanter is very high, heavy and rugose, rising proximally into a blunt point, which extends above the level of the head, and is recurved so as to enclose a large, deep digital fossa. In *Macrauchenia* the great trochanter is much reduced in height, but is very massive and rugose. The second trochanter on the femur of *Theosodon* is quite small, forming a low, thin ridge, and placed quite far below the head. The third trochanter also has a low position on the shaft, nearly midway between the two ends, and projecting pos-

teriorly almost as much as internally. It varies considerably in size in different individuals and, though never very large, it is much better developed and more conspicuous than in *Macrauchenia*.

Proximally, the shaft is broad and strongly compressed and flattened antero-posteriorly, narrowing and thickening downward and becoming subcylindrical above the third trochanter, but with a strong forward curvature. In the Pampean genus, on the other hand, the shaft has a greater degree of antero-posterior flattening throughout. On the postero-external side of the shaft and near the distal end (in *Theosodon*) is a large and rugose pit for the attachment of the plantaris muscle and, on the anterior face, there is a conspicuous suprapatellar fossa. The rotular trochlea is narrow, deeply grooved and somewhat asymmetrical, due to its oblique position and the greater elevation of its internal border; distally, the articular surface is continuous with that of the external condyle, but is quite separate from the inner condyle. The condyles are rather small and irregular and quite widely separated; the external one is narrower and more convex and projects more laterally, the internal one more posteriorly.

The patella (Pl. XX, fig. 4) is a long, narrow, irregular and rather thin bone, the antero-posterior thickness of which is much less than in *Macrauchenia*. The proximal end is obliquely truncate, rising toward the inner side, and the distal end narrows to a blunt point. The anterior face is moderately convex and not very rugose, and the posterior, articular face is divided by an obscurely marked ridge into narrower external and wider internal portions.

The leg-bones, which in *Macrauchenia* are coössified, are entirely separate, and are considerably shorter than the thigh, thus reversing the proportion of the segments which is found in the fore limb.

The tibia (Pl. XX, figs. 5, 5a), which is much shorter than the femur, closely resembles that of *Macrauchenia*, except for its slenderness. The proximal end is very heavy; the external condyle is narrower antero-posteriorly, but more concave than the internal, which is nearly plane. The spine is deeply bifid, and the portion formed by the external condyle is higher, broader and heavier than that which belongs to the inner condyle. The cnemial crest is short, soon dying away upon the shaft, but its proximal portion is very massive and rugose and is deeply impressed by the fossa for the insertion of the great extensor tendon of the thigh.

On the fibular side of the head is a deep sulcus for the tendon of the extensor longus digitorum. The proximal facet for the fibula is small and is confined to the postero-external angle of the tibial head.

The shaft is heavy and nearly straight, with trihedral proximal portion, gradually contracting below and expanding again near the distal end, where it becomes irregularly oval in cross-section. The distal end is narrower and thicker than in *Macrauchenia* and is divided into a broader external, and narrow and deeper internal portion, by a low intercondylar ridge. Anteriorly, this intercondylar ridge is produced into a short, blunt tongue, while the posterior tongue is much more prominent and larger in every dimension. In some individuals the astragalar surface is interrupted by a small, shallow sulcus, which is chiefly on the external condyle and the intercondylar ridge. (See fig. 5*a*.) The internal malleolus is singularly small and confined to the dorsal moiety of the internal side; in *Macrauchenia* this process is still further reduced and has, in fact, almost disappeared. The distal fibular facet is large and oblique.

Of the fibula (Pl. XX, figs. 6, 6*a*) only the distal half is preserved in the collections. That the proximal end was small, is shown by the facet for it on the head of the tibia. The shaft is much more reduced and slender than that of the ulna and its middle portion is quite thin and laterally compressed, though retaining considerable antero-posterior thickness. Distally, the shaft increases steadily in thickness. The distal end which is stout and forms a heavy external malleolus, bears three facets; on the inner side is an inclined surface, which is overlapped by the tibia, and this meets at an obtuse angle the surface for the outer condyle of the astragalus. For the calcaneum is a large distal facet, consisting of an anterior convexity and posterior concavity, though there is no interruption in the continuity of the articular surface. On the outer side of the distal end is a conspicuous groove for the peroneal tendon.

As in the case of the manus, the pes (Pl. XX, fig. 7) is very similar to that of *Macrauchenia*, with only a few minor differences. The tarsus (Pl. XX, figs. 7-9) which is relatively high and narrow, maintains in all respects the character of the Litopterna and differs in points of fundamental significance from that of the Perissodactyla, despite the mesaxonic symmetry of the foot.

The astragalus has quite a perissodactyl appearance, which, however, is entirely superficial in character. The trochlea is deeply grooved and

asymmetrical, owing to the larger size and greater prominence of the external condyle; the neck is moderately elongate and bears, just below the trochlea, a deep fossa, which receives the anterior tongue of the tibia, when the foot is in extreme flexion on the leg. The head, which is depressed and flattened in the dorso-plantar direction, is broad and quite strongly convex; it articulates only with the navicular and is widely removed from any contact with the cuboid. On the plantar side are two facets for the calcaneum, an external one, which is rather small, deeply concave and invaded by a sulcus, so as to be almost divided into two parts; the sustentacular facet, which is narrow and quite widely separate from the external facet, is almost plane.

In *Macrauchenia* the astragalus has a broader and less deeply grooved trochlea, a shorter neck, without fossa for the tibial tongue, and a less convex head. The two plantar facets are much more nearly approximated, and the external one is larger and is not invaded by a sulcus.

The calcaneum of *Theosodon* is very elongate, especially the tuber, which contracts toward the free end, where it again expands in a club-shaped thickening, but has no tendinal groove. The fibular facet, though narrow, is large, conspicuous, strongly convex; the external astragalar facet is in two parts, which meet at an open angle. The sustentaculum is large and prominent and bears a plane, oval facet for the astragalus. The distal end is occupied by the extensive, twisted-looking surface for the cuboid, which is obliquely concave both transversely and planto-dorsally; there is no facet for the astragalus on the inner side of the distal end, the two bones being separated at this point by a narrow space.

In *Macrauchenia* the calcaneum has a relatively shorter and heavier tuber and a smaller facet for the fibula.

The navicular (of *Theosodon*) is rather narrow, but of relatively considerable proximo-distal height, especially the external half of it. From the plantar face is given off an extremely large and prominent process or hook (see Pl. XX, fig. 8) which, though compressed laterally, is yet very heavy. Proximally, the navicular bears quite a deep concavity, to receive the head of the astragalus, and the distal end bears facets for the three cuneiforms. That for the entocuneiform is small and obliquely lateral rather than distal in position, that for the mesocuneiform is larger, while the facet for the ectocuneiform is still larger and descends farther distally, which gives an appearance as though a step were cut in the navicular to receive the mesocuneiform.

In *Macrauchenia* the navicular is very similar, but is relatively shorter proximo-distally and the step on the distal end is less distinct.

The entocuneiform is a long, narrow, scale-like bone, convex on the tibial and concave on the fibular side, and with abruptly truncated distal end. Proximally, there is an oblique, concave facet for the navicular, below this a small lateral facet for the mesocuneiform, and near the distal end and dorsal border a small, oval surface for the second metatarsal. The mesocuneiform is a relatively large, irregularly oval bone, broadest on the dorsal side; the navicular facet is slightly concave in the dorso-plantar direction, and that for the second metatarsal is saddle-shaped. Other facets are a small one on the tibial side, near the plantar and proximal edges, for the entocuneiform, and a still smaller one on the fibular side for the ectocuneiform.

The ectocuneiform is very large; the dorsal face is nearly square, though somewhat higher than it is wide, and thence the bone narrows to a blunt edge on the plantar side, which bears a small, rugose tuberosity. Proximally, the surface for the navicular is irregularly concave in front, convex behind, while the distal facet for the third metatarsal is quite deeply concave planto-dorsally. On the tibial side, near the distal end, are two widely separated facets for the second metatarsal, a small one near the dorsal and a large one near the plantar border. Articulation with the cuboid is limited to a small facet on the fibular side near the proximal end.

The cuboid is a very large bone and, though widely separated from the astragalus, is yet relatively high proximo-distally. The proximal surface rises steeply toward the plantar side, making the height of the bone nearly twice as great on this side as it is on the dorsal. On the tibial side are three facets for the navicular, two near the proximal end and plantar side, and the third a projection from about the middle of the tibial face, upon which the navicular rests and which bears also a small facet for the ectocuneiform. The fibular side has two prominent tubercles and, between them, a tendinal sulcus. Distally, is a very large, concave surface for the fourth metatarsal, and, external to this a minute facet for the vestigial fifth, which is more lateral than distal in position.

The metatarsus consists of similar elements to those of the metacarpus, three functional members arranged in mesaxonic symmetry, and a vestige of another, the fifth.

Metatarsal II is long and heavy; the head is narrow, but thick, and has a prominent hook-like projection from the plantar side. On the tibial side, below the head, is a small concave facet for the entocuneiform. This metatarsal rises far above the proximal end of mt. III and has an extensive lateral bearing against the ectocuneiform by means of two facets, one near the dorsal border and the other upon the plantar process. Beneath the dorsal facet for the ectocuneiform is an elongate, narrow surface for articulation with mt. III. The shaft is stout and trihedral, with rounded borders, and the distal trochlea resembles that of mc. II, with the very prominent carina extending over the dorsal face.

Metatarsal III is somewhat longer than mt. II, but as its proximal end is at a lower level than that of the latter, its effective length is considerably greater. The head is broad and thick, ending behind in a prominent plantar hook, and carries a large surface for the ectocuneiform, which is convex planto-dorsally, slightly concave transversely. On the tibial side, near the dorsal border, is a facet for mt. II and another on the plantar hook, and on the fibular side are two facets, in corresponding positions for mt. IV. The shaft is straight, slender and subquadrate, widening somewhat near the distal end. The very prominent carina is plantar and distal; on the dorsal face it is very obscurely indicated, being even less distinct than in the corresponding metacarpal.

Metatarsal IV is the counterpart of mt. II, but is a little shorter and heavier. A plantar hook is present, as in the other metatarsals, and the irregularly convex cuboid surface extends the full depth of this hook. On the fibular side of the head are two small facets for the vestigial mt. V, and on the tibial side are two others for mt. III, the dorsal one a prominent convexity and the plantar one circular and plane. The distal end is asymmetrical, with a large rugose tuberosity on the fibular side, and the carina is prominent on the dorsal face of the trochlea.

Metatarsal V has not yet been found, but its presence and its vestigial character are indicated by the facets on mt. IV and the cuboid.

The phalanges of the pes are so like those of the manus as to require no particular description.

Restoration (Pl. XVI).—Of the many curious animals which make up the Santa Cruz fauna, few can have had a more remarkable appearance than *Theosodon*. In size, there is no great difference among the various species so far found in the Santa Cruz formation, the best known species,

T. garrettorum, is considerably taller and stouter than the llama, to which it bears some resemblance in general proportions. The head is rather large, but low and the much shortened nasals and immense, tapir-like anterior nares give it a highly peculiar and characteristic appearance. The long, slender rostrum and mandible, and the conical, sharp-pointed and slightly recurved anterior teeth are almost reptilian in effect. The long neck and limbs and the rather short trunk and very short tail are the especial features which recall the proportions of the llamas, but the much shorter tridactyl feet and separate metapodials form a striking difference from any of the existing Tylopoda. An unusual character is to be found in the relative lengths of the limb-segments; the upper arm is short and the fore-arm very long, while in the hind limb this proportion is reversed, the thigh being long and the leg short.

The skeleton of *Macrauchenia* bears an unmistakable resemblance to that of *Theosodon*, but, in addition to the numerous differences of detail described in the preceding pages, there are some obvious differences of proportion. *Macrauchenia* was a much larger animal than the Santa Cruz genus and has relatively longer limbs, with which the elongation of the neck has not kept pace. The skull, in adaptation to the growth of the proboscis, has become quite different in appearance and the trunk is probably shortened, though this is not altogether certain. At all events, the trunk-vertebræ are proportionately smaller and have more slender spines, which are more inclined in the anterior part of the thoracic region and more erect in the lumbar. The scapula is much narrower than in *Theosodon* and the acromion and metacromion are far less developed, while the pelvis is shorter, is set more nearly vertical to the axis of the spinal column and has the iliac plates much more strongly everted. These differences are just what we should expect to find between ancestor and descendant and, so far as present knowledge is concerned, there is no reason why we should not regard *Theosodon* as directly ancestral to the Pampean *Macrauchenia*.

Synonymy.—The isolated position of *Theosodon* in the Santa Cruz fauna is such that there has been little difference of opinion as to the proper nomenclature. Lydekker ('93, 65) has made this genus a synonym of *Oxydontotherium* from the much later Paraná beds, but with this view I am quite unable to agree, on account of the differences in tooth-structure, not to mention the highly probable differences in the skull. Ameghino

has described a genus, *Pseudocælosoma*, which he believes to be distinct from *Theosodon*, but which is here regarded as a synonym of the latter. In the original description ('91n, 294) the very large, single inner root of the upper molars is given as the diagnostic character, but, as already pointed out (p. 110), this is true of all the species of *Theosodon*. In a subsequent paper ('04, 54) he writes that this animal shows numerous differences from the last-named genus, the only one of which mentioned is, however, the presence of a pillar of the cingulum between the internal cusps of the upper molars. As we have seen (p. 109), this is too variable a character to be of generic significance.

THEOSODON LYDEKKERI Ameghino.

(Plates XVII, Figs. 3, 3a; XX, Figs. 6-7.)

Theosodon Lydekkeri Ameghino; Enum. sistemática, etc., 1887, p. 19.

The original description of this species is founded upon fragments of a large animal, the upper molar-series having an antero-posterior length of 73 mm. Ameghino's subsequent descriptions of much more complete material, assigned to this species, all refer to considerably smaller individuals with upper molar-series 62 mm. in length, or less. Such a difference of size, nearly 17 per cent., would not of itself be a sufficient reason for the specific distinction between the larger and the smaller individuals, but two circumstances lead me to the conclusion that such a distinction should be made. (1) The difference in size is very constant and in a large series of specimens there is no perceptible tendency to approximation, though, no doubt, a still larger series would show some such tendency. This constancy is in very marked contrast to the conditions seen in *Proterotherium*, in which size is extremely variable and wide differences are connected by every intermediate gradation. (2) The milk-premolars of the larger animals differ decidedly from those of the smaller, especially dp^3 and 4 , which have much larger internal crescents and prominent posterior pillars on the external face. Whether the permanent premolars show a similar difference the known material does not enable me to say. In my judgment, therefore, the name *T. lydekkeri* should be restricted to the large individuals, which are, unfortunately, but very inadequately represented in the collections.

The following measurements are taken from a young, incomplete skull (No. 15,717) in which m^1 has just come into use and m^2 is still concealed in the jaw.

MEASUREMENTS.

Upper milk-premolar series, length.	.074	Dp ³ , width	.017
Dp ¹ , length (<i>i. e.</i> , ant.-post. diam.)	.013	Dp ⁴ , length	.022
" width (<i>i. e.</i> , greatest trans. diam.)	.007	" width	.0195
Dp ² , length	.0195	M ¹ , length	.024
" width	.015	" width	.0223
Dp ³ , length	.019		

In the collection of the American Museum of Natural History is a hind foot (No. 9219), lacking the calcaneum, astragalus and navicular, which is apparently referable to this species. The specimen is figured in Pl. XX, fig. 7, with the missing parts supplied from other individuals. In one respect this foot is manifestly abnormal (not shown in the drawing) namely, in the disproportionate width of the distal end of metatarsal III and the adjoining part of the first phalanx. This width is undoubtedly due to disease or accident in the lifetime of the animal.

Metatarsal II, length	.134	Phalanx 1, digit II, distal thickness	.016
" " proximal width	.020	" 2, " " length	.037
" " " thickness	.032	" 2, " " prox. width	.027
" " distal width	.029	" 2, " " " thickness	.022
" " " thickness	.029	" 2, " " dist. width	.025
Metatarsal III, length	.146	Ungual phalanx, digit II, prox. width	.022
" " proximal width	.023	" " " " dist. width.	.030
" " " thickness.	.035	Phalanx 1, digit III, length	.057
" " distal width	.040*	" 1, " " prox. width	.039*
" " " thickness	.029*	" 1, " " " thickness	.028*
Metatarsal IV, length	.127	" 1, " " distal width	.024
" " proximal width	.024	Phalanx 2, digit III, length	.034
" " " thickness.	.034	" 2, " " prox. width	.025
" " distal width	.028	" 2, " " dist. width	.022
" " " thickness	.028	Phalanx 1, digit IV, prox. width	.029
Phalanx 1, digit II, length	.054	" 1, " " dist. width	.023
" 1, " " prox. width	.029	Phalanx 2, digit IV, length	.033
" 1, " " " thickness	.021	" 2, " " prox. width	.025

* Pathological.

Localities. — Not given for type. No. 15,717 was collected by Mr. Peterson 10 miles south of Coy Inlet.

THEOSODON LALLEMANTI Mercerat.

(Plates XVII, Fig. 4; XVIII, Figs. 1, 1a, 3, 3a, 7, 9; XIX, Fig. 1; XX, Figs. 3, 3a.)

Theosodon lallemanti Mercerat; Rev. del Mus. de La Plata, T. II, 1891, p. 48.

Theosodon Frenzeli Mercerat ; Ibid.

Theosodon lydekkeri Amegh., in part ; Rev. Argent. de Hist. Nat., T. I, 1891, p. 294 ; Énum. Synopt., etc., 1894, p. 28 ; Les Ongulés fossiles de l'Argentine, Rev. del Jard. Zool. de Buenos Aires, T. II, 1894, p. 280.

Oxyodontotherium lydekkeri Lydekker ; Anales del Mus. de La Plata, T. II, 1893, p. 66.

If the restriction of the name *T. lydekkeri* to the larger animals, as suggested in the foregoing paragraphs, be correct, the oldest name available for the present species is *T. lallemanti* Mercerat, though our knowledge of the animal is almost exclusively due to the work of Ameghino, who has briefly described and fully illustrated the dentition, skull and feet.

T. lallemanti, which is much the commonest of the Santa Cruz species, may be distinguished not only by its size, but also by certain features in the dentition and skull. The upper molars may or may not have the two inner cusps connected by a cingulum and thus in worn teeth either two or three enamel lakes may appear, a very variable feature. The milk premolars are quite different from those of *T. lydekkeri*, dp^2 and 3 having much smaller and more symmetrical internal crescents and less developed pillars on the external face. The sagittal crest is high and thin, expanding anteriorly into a long, narrow sagittal area. The nasal processes of the frontals are very short and narrow, and the nasals, though greatly shortened, are longer than in *T. garrettorum*, projecting farther in advance of the maxillary border, and are in contact throughout their length.

In the table, No. 1 is the type of *T. lallemanti* and No. 2 that of *T. frenzeli*, the dimensions in both cases being taken from Mercerat's paper.

MEASUREMENTS.

	No. 15,216.	No. 1.	No. 2.	No. 16,003.
I ² , length			.0108	
Upper premolar-molar series, length				.131
“ premolar series, length				.071
P ¹ , length (<i>i. e.</i> , antero-posterior diameter)			.015	.013
“ width (<i>i. e.</i> , transverse diameter)				.010
P ² , length		.0178	.0169	.018
“ width				.018
P ³ , length		.0179	.018	.020
“ width				.021
P ⁴ , length		.020	.0206	.018

	<i>No.</i> 15,216.	<i>No.</i> 1.	<i>No.</i> 2.	<i>No.</i> 16,003.
P ⁴ , width				.022
Upper molar series, length				.060
M ¹ , length		.0215		.020
“ width				.023
M ² , length		.0234	.024	.0205
“ width				.0235
M ³ , length				.020
“ width				.022
I ₁ , length		.014		
I ₂ , “		.0145		
I ₃ , “		.0155		
Lower canine, length		.0167		
P ₁ , length		.0198	.0175	
P ₂ , “	.019	.0214	.020	
P ₃ , “	.020	.022		
P ₄ , “	.0225	.0226		
Lower molar series, length	.066			
M ₁ , length	.022	.0226	.025	
M ₂ , “	.023	.023	.024	
M ₃ , “	.0215	.0226		

The measurements of the milk-teeth and associated molars are taken from two individuals, those of the upper jaw from No. 15,359 and those of the lower jaw from No. 16,002.

Di ² , length	.0093	Di ₁ , length	.008
“ width	.0043	“ width	.004
Di ³ , length	.010	Di ₂ , length	.0115
“ width	.005	“ width	.005
D ^c , length	.0115	Di ₃ , length	.0125
“ width	.0055	“ width	.005
Upper milk-premolar series, length.	.068	D _c , length	.014
Dp ¹ , length	.012	“ width	.0055
“ width	.007	Lower milk-premolar series, length.	.061
Dp ² , “	.011	Dp ₁ , length	.016
Dp ³ , length	.017	“ width	.006
Dp ⁴ , “	.019	Dp ₂ , length	.020
Upper molar series, length	.062	“ width	.008
M ¹ , length	.021	Dp ₃ , length	.0235
“ width	.020	“ width	.009
M ² , length	.022	Dp ₄ , length	.025
“ width	.021	“ width	.013
M ³ , length	.018	M ₁ , length	.022
“ width	.018	“ width	.014
Lower milk-dentition, length	.111		

Ameghino gives the following measurements of his specimen: Length of skull from condyles to premaxillaries, 32 cm.; length of lower dentition from i_1 to m_3 , 19 cm.; depth of mandible below p_2 , 31 mm. ('91g, 294).

A considerable number of skeletal parts are associated with the jaw, No. 15,216, and from this individual the following dimensions have been taken. These bones show that *T. lalleменти* is a stoutly built animal, and that the trunk-vertebræ have heavy spines. Especially in the lumbar region are the neural spines high and very broad antero-posteriorly. The third trochanter of the femur is large and prominent.

MEASUREMENTS.

Atlas, length	.065	5th lumbar, width of anterior face	.035
“ dorso-ventral height	.047	“ “ “ “ posterior face.	.030
Axis, length incl. odontoid	.117	“ “ dorso-ventral height	
“ “ excl. “	.096	incl. neural spine	.119
“ width of anterior face	.043	Sacrum, length	.162
3d cervical, length of centrum	.104	“ anterior width of centrum.	.033
“ “ width of anterior face	.040	“ “ “ overpleurap.	.154
6th cervical, length of centrum	.076	“ posterior width of centrum.	.018
“ “ width of anterior face	.042	Scapula, length in median line	.245
7th cervical, length of centrum	.048	“ width of neck	.052
“ “ width of anterior face	.0415	Pelvis, length	.377
13th thoracic, length of centrum	.044	“ width over iliac plates	.390
“ “ width of anterior face.	.034	“ “ “ ischial tuber.	.172
14th thoracic, length of centrum	.045	Acetabulum, ant.-post. diameter	.051
“ “ width of anterior face.	.038	“ transverse “	.042
1st lumbar, length of centrum	.049	Pubic symphysis, length	.098
“ “ width of anterior face	.038	Humerus, length from head	.239
“ “ dorso-ventral height		“ “ “ ext. tuber.	.251
incl. neural spine	.125	“ width of trochlea	.047
2d lumbar, length of centrum	.047	“ “ over epicondyles	.066
“ “ width of anterior face	.036	Femur, distal width	.074
3d lumbar, length of centrum	.049	“ “ thickness	.092
“ “ width of anterior face	.036	Tibia, length including spine	.260
4th lumbar, length of centrum	.052	“ proximal thickness	.081
“ “ width of anterior face	.038	“ distal width	.046
5th lumbar, length of centrum	.048	“ “ thickness	.041

Localities.—Neither Ameghino nor Mercerat give localities for their specimens. No. 15,359 was found by Mr. Hatcher at Killik Aike, and No. 15,216 was collected by Mr. Peterson 5 miles south of Coy Inlet.

THEOSODON GARRETTORUM sp. nov.

(Plates XVI; XVII, Figs. 1, 2, 5; XVIII, Figs. 2, 4, 4a, 6, 8, 8a, 10; XIX, Figs. 1a, 2, 5-7; XX, Figs. 2, 5, 5a.)

This species is of very nearly the same size as the preceding one, but differs from it in a number of well-defined characters. The type-specimen is the nearly entire skeleton (No. 15,164) figured in Plate XVI, though completed with some addition of missing details from other species. The name is given in honor of Messrs. John W. and Robert Garrett, of Baltimore, whose generosity has been one of the mainstays of the Patagonian expeditions.

The permanent dentition is essentially similar to that of *T. lallemanti*, but there is no cingulum between the inner cusps of the upper molars and m^3 is more reduced in size, and in p^3 the anterior inner fossa is not so deeply concave.

MEASUREMENTS.

Upper dentition, extreme length	.190	M^2 , width	.019
I^1 , major diameter	.010	I^2 , major diameter	.013
" minor diameter	.006	" minor diameter	.0085
I^2 , major diameter	.011	I^3 , major diameter	.013
" minor diameter	.008	" minor diameter	.0085
I^3 , major diameter	.011	Lower canine, major diameter	.014
" minor diameter	.008	" " minor diameter	.009
Upper canine, ant.-post. diameter	.0125	Lower premolar-molar series, length	.140
" " transverse diameter	.009	" premolar series, length	.070
Upper premolar-molar series, length	.137	P^1 , length	.015
" premolar series, length	.074	" width	.009
P^1 , length (<i>i. e.</i> , ant.-post. diam.)	.015	P^2 , length	.018
" width (<i>i. e.</i> , greatest trans. diam.)	.009	" width	.0095
P^2 , length	.0165	P^3 , length	.021
" width	.016	" width	.012
P^3 , length	.018	P^4 , length	.022
" width	.018	" width	.0135
P^4 , length	.0195	Lower molar series, length	.070
" width	.020	M^1 , length	.0225
Upper molar series, length	.063	" width	.015
M^1 , length	.020	M^2 , length	.023
" width	.0225	" width	.019
M^2 , length	.0225	M^3 , length	.023
" width	.024	" width	.015
M^3 , length	.0195		

The milk-dentition of this species is not definitely known, but a frag-

ment of mandible (No. 15,378) with $dp_{\overline{3}}$ and $\overline{4}$ and the alveolus of $m_{\overline{1}}$, is probably referable to it, as is indicated by the unusual shallowness and thickness of the horizontal ramus.

MEASUREMENTS.

$Dp_{\overline{3}}$, length.	.024	$Dp_{\overline{4}}$, length.	.026
" width	.010	" width	.012

In construction, these teeth display no noteworthy differences from those of *T. lallemanti*.

The skull, which in the type-specimen has suffered some distortion and dorso-ventral flattening from pressure, differs from that of *T. lallemanti* in a number of significant details. The cranium is shorter, the brain-case more rounded, and the sagittal crest is shorter and the anterior sagittal area is narrower; the nasal processes of the frontals are very much more developed, especially in transverse width, and widely separate the nasals, which are not in contact with each other at any point. The nasals themselves are considerably shorter than in the preceding species and are attached for their whole length to the maxillaries, not projecting freely beyond them, as they do in *T. lallemanti*. The free dorsal border of the maxillaries is thinner and less rounded and anteriorly these bones send out processes between the premaxillaries, almost excluding the latter from forming any part of the narial opening, while in *T. lallemanti* they are more extensively concerned in bounding the opening. Finally, the horizontal ramus of the mandible is distinctly more shallow in the dorso-ventral dimension than in *T. lallemanti* and has a thicker and more rounded ventral border. If the very young mandible above mentioned (No. 15,378) be properly referred to *T. garrettorum*, then the difference in the character of the ramus is even more marked in the young than in the adult.

Owing to the crushing to which the skull has been subjected, not many measurements can be profitably given.

MEASUREMENTS.

Skull, length in median basal line	.323	Occiput, width at base	.079
" " cond. to prmx.	.339	Nasals, length	.047
" extreme length	.349	Mandible, depth below $p_{\overline{3}}$	.028
Cranium, length to ant. rim of orbit	.177	" " " $m_{\overline{3}}$	.033
Face, length orbit to prmx.	.179	" height of condyle	.081

The skeleton has been very fully described in the account of the genus

and material is wanting for a comparison of the different species in regard to the variations in skeletal structure among them. It may, however, be pointed out that in *T. garrettorum* the vertebræ, especially in the lumbar region, have shorter, narrower and more slender spines than those of *T. lallemanti* and that the third trochanter of the femur is less prominently developed.

MEASUREMENTS.

Atlas length.	.067	Radius, distal width	.042
“ width over transv. proc.	.101	“ “ thickness.	.028
“ dorso-ventral height	.047	Ulna, length.	.375
3d cervical, length of centrum	.105	“ prox. width at rad. facets	.053
“ “ width of anterior face.	.043	“ distal width.	.017
6th cervical, length of centrum	.072	“ “ thickness	.036
“ “ width of anterior face.	.041	Carpus, length in median line.	.036
7th cervical, length of centrum	.048	“ width	.062
“ “ width of anterior face.	.045	Metacarpal II, length	.130
1st thoracic, length of centrum	.038	“ “ proximal width	.026
“ “ width of anterior face.	.037	“ “ “ thickness.	.026
2d thoracic, length of centrum	.035	“ “ distal width	.024
“ “ width of anterior face	.034	“ “ “ thickness	.026
10th thoracic, length of centrum	.040	Metacarpal III, length	.145
“ “ width of anterior face	.036	“ “ proximal width	.025
Last thoracic, length of centrum	.045	“ “ “ thickness.	.028
“ “ width of anterior face	.040	“ “ distal width	.025
2d lumbar, length of centrum	.048	“ “ “ thickness	.0245
“ “ width of anterior face	.040	Metacarpal IV, length	.122
4th lumbar, length of centrum.	.048	“ “ proximal width	.024
“ “ width of anterior face	.0395	“ “ “ thickness.	.025
Last lumbar, length of centrum	.037	“ “ distal width	.0245
“ “ width of anterior face.	.038	“ “ “ thickness	.0245
“ “ “ “ posterior face	.027	Phalanx 1, digit II, length	.058
Sacrum, length	.171	“ 1, “ “ prox. width	.0245
“ anterior width of centrum.	.030	“ 1, “ “ “ thickness	.022
“ posterior “ “ “	.012	“ 1, “ “ distal width	.020
Scapula, length	.253	“ 1, “ “ “ thickness	.016
“ width of neck	.052	Phalanx 2, digit II, length	.028
Humerus, length from head	.234	“ 2, “ “ proximal width	.0245
“ “ “ ext. tuber.	.255	“ 2, “ “ distal width	.020
“ proximal thickness.	.090	Ungual phalanx, digit II, length	.0225
“ dist. width over trochlea	.050	“ “ “ “ width	.025
“ “ “ “ epicondyles	.070	Pelvis, length	.305
Radius, length	.311	Ilium, length	.192
“ proximal width.	.035	“ greatest width	.237
“ “ thickness	.023	“ width of peduncle	.058

MEASUREMENTS.

Ischium, length	.114	Astragalus, width of trochlea.	.0415
Femur, length from head	.325	Metatarsal II, length	.134
“ proximal width	.099	“ “ proximal width	.019
“ distal width	.073	“ “ “ thickness	.031
“ “ thickness.	.086	“ “ distal width	.025
Tibia, length with spine.	.271	“ “ “ thickness	.026
“ proximal width	.081	Metatarsal III, length	.142
“ “ thickness	.077	“ “ proximal width	.021
“ distal width.	.053	“ “ “ thickness.	.033
“ “ thickness	.044	“ “ distal width	.027
Astragalus, length	.058	“ “ “ thickness-	.0255

Localities.—The type (No. 15,164) was collected by Mr. Peterson ten miles south of Coy Inlet and the jaw fragment with milk-teeth (No. 15,378) which is probably referable to this species, was also found by Mr. Peterson at the same place.

THEOSODON FONTANÆ Ameghino.

Theosodon Fontanæ Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 294.

Oxydontotherium Fontanæ Lydekker; Anales del Mus. de La Plata, T. II, 1893, p. 67.

No specimens definitely referable to this species are contained in the Princeton or New York collections. According to the original description, *T. fontanæ* is about the same size as *T. lallemanti*, but relatively more robust; the anterior part of the rostrum is shorter and broader; the molars are heavier and the incisors and premolars are set more closely together, not so spaced apart. (Ameghino, *loc. cit.*)

THEOSODON GRACILIS Ameghino.

(Plate XX, Figs. 1, 1a, 4, 8.)

Theosodon gracilis Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 295.

Theosodon patagonensis Mercerat; Rev. del Mus. de La Plata, T. II, 1891, p. 48 (*fide* Ameghino).

Theosodon debilis Mercerat; Ibid., p. 49 (*fide* Ameghino).

Oxydontotherium angustidens Lydekker; Anales del Mus. de La Plata, T. II, 1893, p. 69.

This species is a little smaller than *T. lallemanti* and of more slender

proportions, the rostrum and symphyseal region of the mandible are narrower and more pointed, and more or fewer of the anterior teeth tend to wear into horizontal instead of pyramidal grinding surfaces. This latter feature, however, would appear to be less constant than Ameghino has supposed.

In the collection of the American Museum is a skull (No. 9230), apparently referable to this species, from which the following dimensions have been taken.

MEASUREMENTS.

Upper dentition, length i^1 - m^3	.178	I_3 , major diameter	.0113
I^2 , major diameter	.011	" minor diameter	.009
" minor diameter	.010	Lower canine, major diameter	.013
I^3 , major diameter	.011	" " minor diameter	.011
" minor diameter	.010	Lower premolar series, length	.071
Upper canine, major diameter	.012	P_1 , length	.014
" " minor diameter	.011	" width	.0105
P^2 , length (<i>i. e.</i> , ant.-post. diam.)	.017	P_2 , length	.017
" width (<i>i. e.</i> , greatest trans. diam.)	.0155	" width	.010
P^3 , length	.017	P_3 , length	.019
" width	.020	" width	.011
P^4 , length	.017	P_4 , length	.021
" width	.022	" width	.013
Upper molar series, length	.058	M_1 , length	.020
M^1 , length	.018	" width	.013
" width	.022	M_2 , length	.022
M^2 , length	.021	M_3 , width	.014
" width	.0225	Skull, length in median basal line	.295
M^3 , length	.021	" " condyle to prmx.	.317
" width	.021	" extreme length	.337
I_1 , major diameter	.008	Cranium, length cond. to rim of orbit	.168
" minor diameter	.007	Face, length orbit to premaxillary	.163
I_2 , major diameter	.011	Occiput, width at base	.081
" minor diameter	.0085	Mandible, depth below p_3	.038

A fragmentary skeleton (No. 15,798) obtained by Mr. Hatcher at Lake Pueyrredon may be provisionally referred to this species, with which it agrees fairly well in size, but the diagnostic portions of the skull are wanting.

MEASUREMENTS.

P^3 , length	.016	" width	.018
" width	.018	M^1 , length	.018
P^4 , length	.0175	" width	.0205

MEASUREMENTS.

Axis, width of anterior face . . .	.062	Astragalus, length . . .	.053
Femur, proximal width . . .	.091	" width of trochlea. . .	.037
" distal width over condyles . . .	.0745	" " " distal end . . .	.030
Tibia, proximal width . . .	.070	Metatarsal II, length . . .	.122
" distal width. . .	.050	" " proximal width . . .	.021
" " thickness . . .	.039	" " " thickness . . .	.029
Tarsus, length in median line . . .	.074	" " distal width . . .	.0245
" width . . .	.051	Metatarsal III, distal width . . .	.024
Calcaneum, length . . .	.111	Metatarsal IV, length . . .	.116
" width over sustentaculum . . .	.041	" " proximal width . . .	.0215
		" " distal width . . .	.025

Localities.—Neither Ameghino, Mercerat, nor Lydekker gives any localities for their specimens. No. 9230 was collected by Mr. Brown at Halliday's Ranch on the Rio Gallegos and No. 15,798 by Mr. Hatcher at Lake Pueyrredon.

THEOSODON PATAGONICUS (Ameghino).

Pseudocaelosoma patagonica Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 294.

It has been pointed out in the foregoing pages that in several species of *Theosodon* the two internal cusps of the upper molars are often connected by a cingulum, but this is a very variable feature, differing even in the two sides of the same jaw. Thus, in well worn teeth, the number of enamel-lakes may be either two or three. In *T. patagonicus* the cingulum is replaced by a pillar, in what appears to be a very constant fashion, and equally constant is the presence of three lakes in the abraded grinding surfaces. The species is not represented in the Princeton or New York collections.

Localities.—Not given.

THEOSODON KARAIKENSIS Ameghino.

Theosodon karaiensis Amegh.; Nuev. Espec. de Mamíf. Cretac. y Terc., 1904, p. 54.

Very inadequately known from two molars, an upper and a lower, which leave the specific characters much in doubt. The distinctness of the species is, however, made probable by the horizon in which it occurs.

Locality.—Kar Aike.

ADIANTHUS Ameghino.

Adianthus Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 134.

Adiantus Amegh.; Énum. Synopt., etc., 1894, p. 27.

This genus is known to me only from the author's descriptions, which are substantially as follows: The third upper molar resembles that of *Macrauchenia* in miniature, with similar number and arrangement of the enamel lakes, but the external face lacks the mesostyle, which is replaced by a depression. There are two external roots and one internal, the latter very broad. (Ameghino, '04b, 52.)

The mandibular dentition has the formula, $I_{\overline{3}}$, $C_{\overline{1}}$, $P_{\overline{4}}$, $M_{\overline{3}}$, and the teeth are arranged in continuous series. The lower molars differ from those of *Theosodon* in having no trace of the spur or pillar in the posterior crescent. The incisors are small and placed in the same longitudinal line as the grinding teeth. The canine resembles the incisors in form and the anterior premolars are like the canine, and the posterior premolars intermediate in character between the anterior premolars and the molars. From the first incisor to the last molar there is a gradual and successive modification of form. The horizontal ramus of the mandible has a straight inferior border and is of nearly uniform dorso-ventral depth throughout. (Ameghino, '94a, 27, 28.)

ADIANTHUS BUCCATUS Ameghino.

Adianthus buccatus Amegh.; Rev. Argent. de Hist. Nat., T. I, 1891, p. 134.

Adiantus buccatus Amegh.; Énum. Synopt., etc., 1894, p. 28.

This is a very small animal, far smaller than any species of *Theosodon*. The lower dentition is 62 mm. long; $m_{\overline{1}}$ is 7 and $m_{\overline{2}}$ 9 mm. in length, and the horizontal ramus below $m_{\overline{1}}$ is 14 mm. in dorso-ventral depth. (Ameghino, '94a, 28.)

Localities. — Not given.

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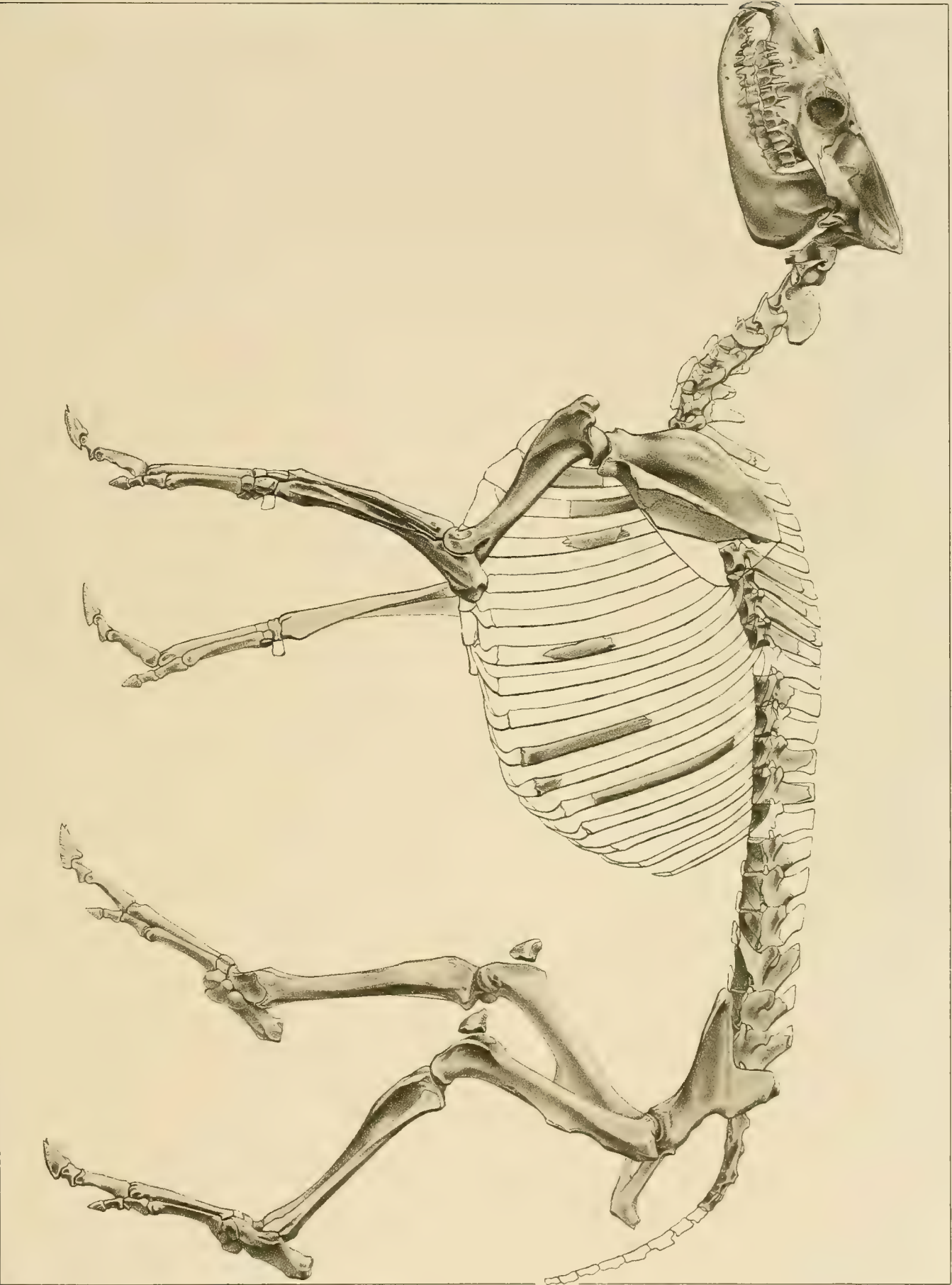
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PATAGONIAN EXPEDITIONS: PALÆONTOLOGY.

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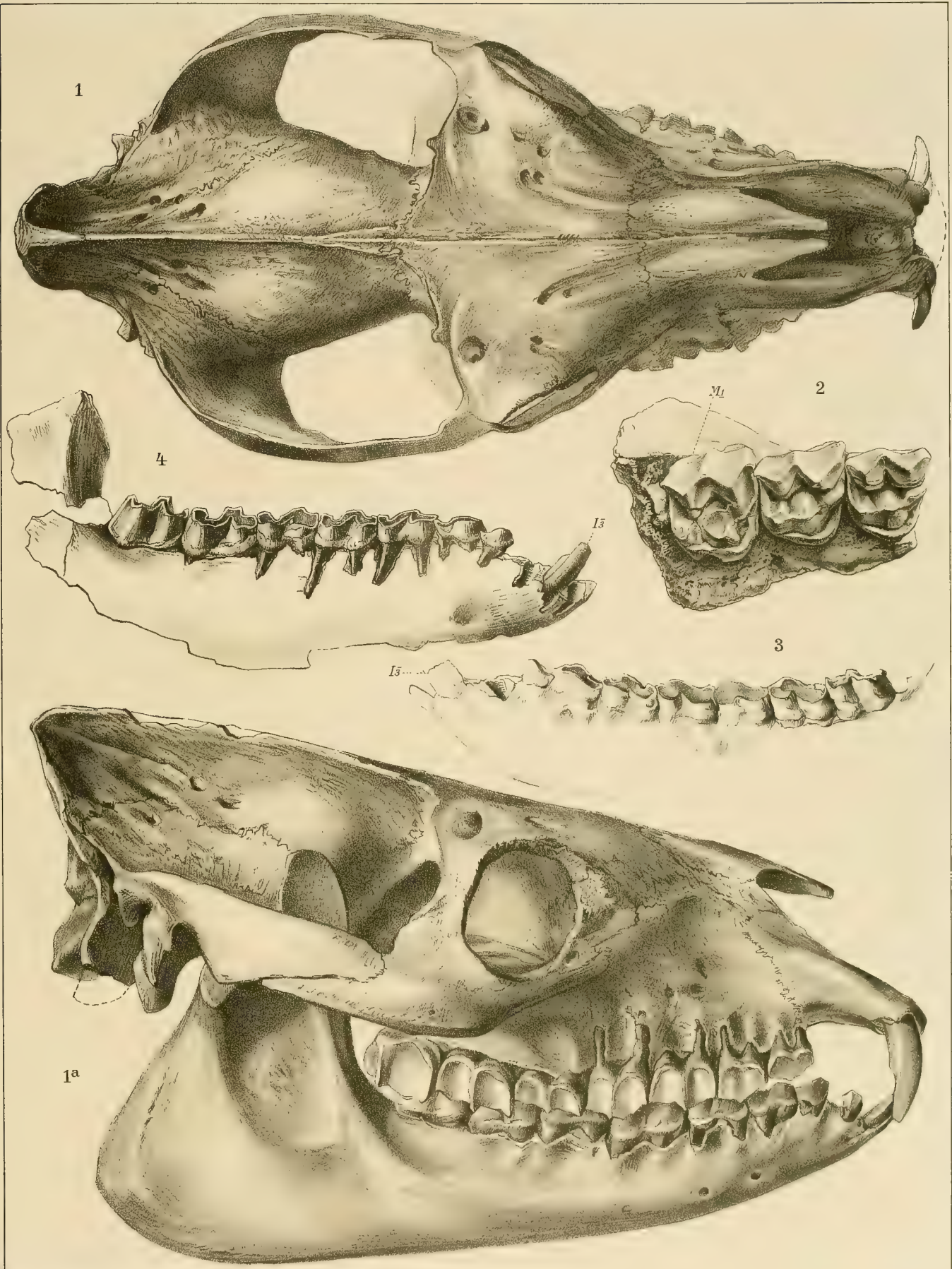


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DIADIAPHORUS

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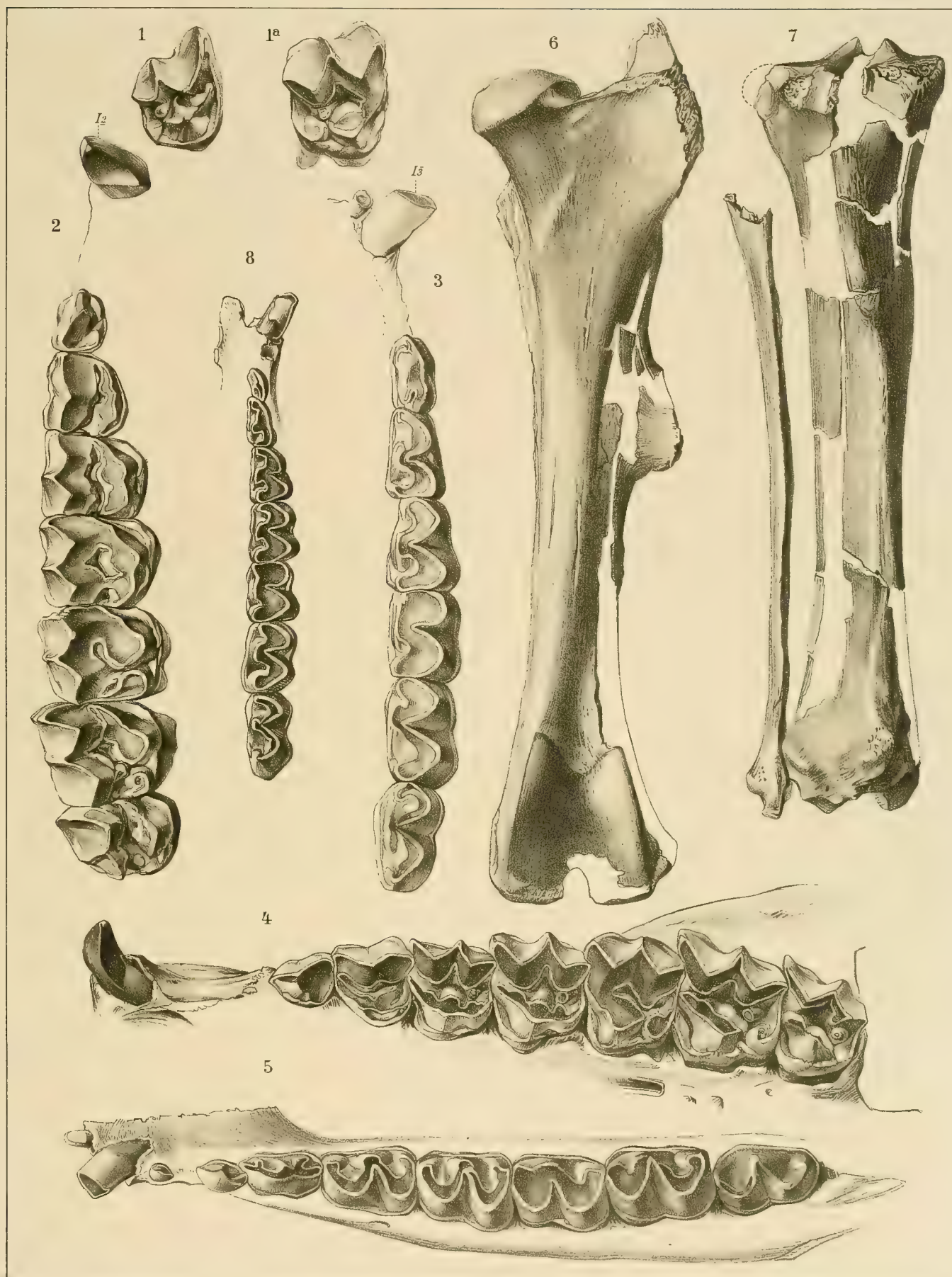
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$\Delta \rho = \rho_0 - \rho_{\infty} = \frac{1}{2}(\rho_0 + \rho_{\infty}) \left(\frac{\rho_0 - \rho_{\infty}}{\rho_0 + \rho_{\infty}} \right)^2$

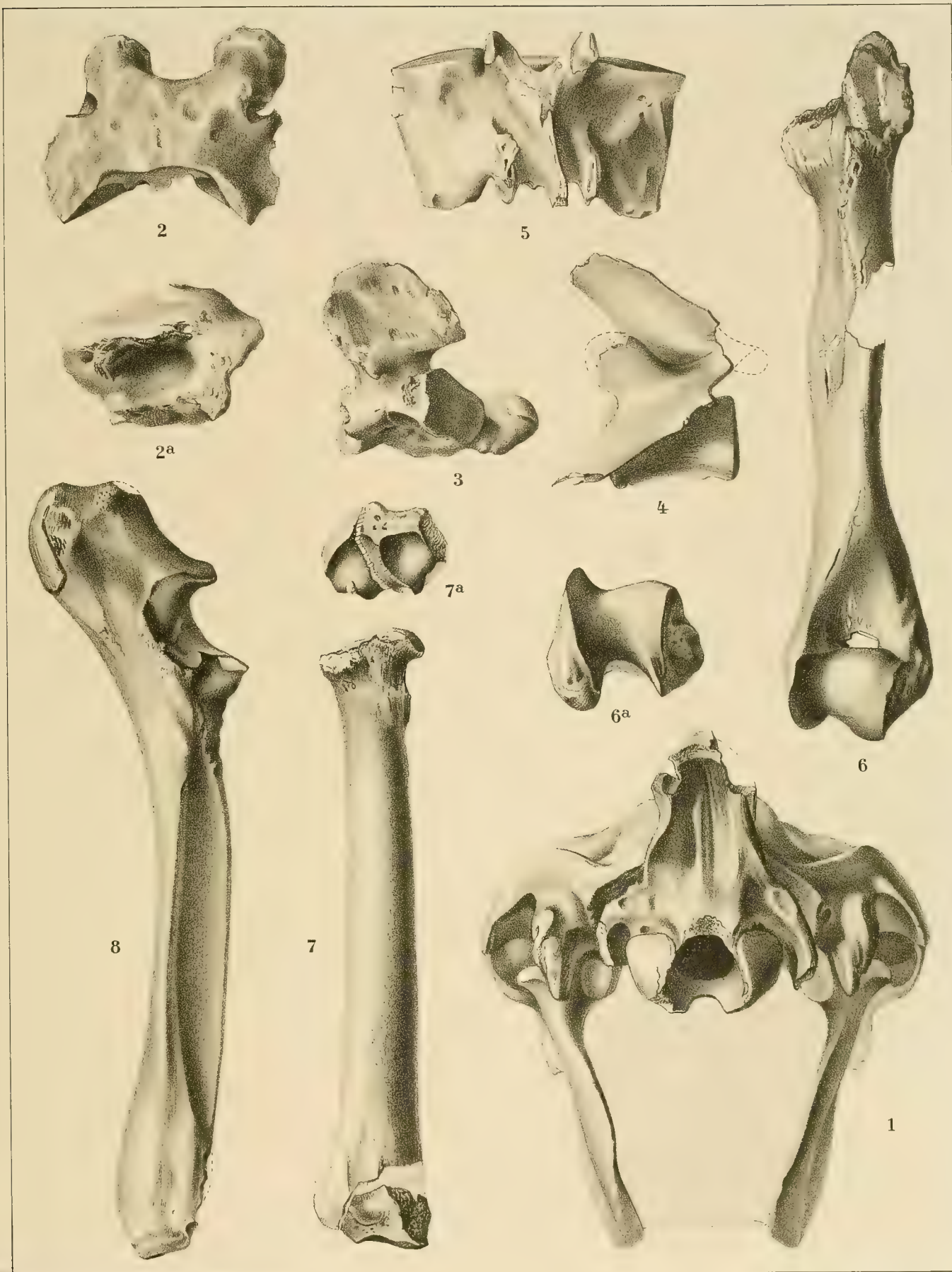
DIADIAPHORUS

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All the figures are three-fourths natural size and, except Fig. 1, all are from No. 15,799.



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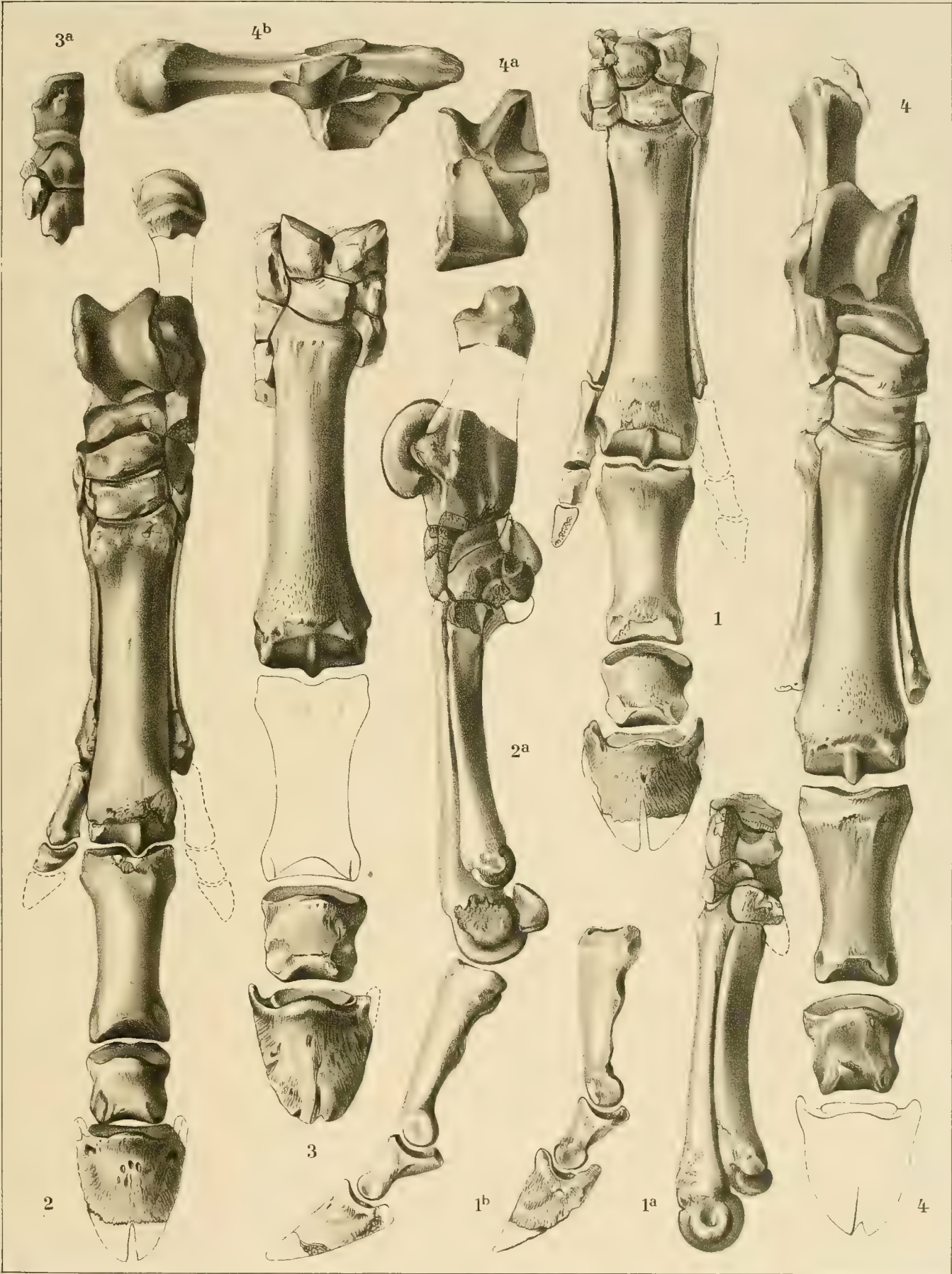
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All the figures are three-fourths natural size.



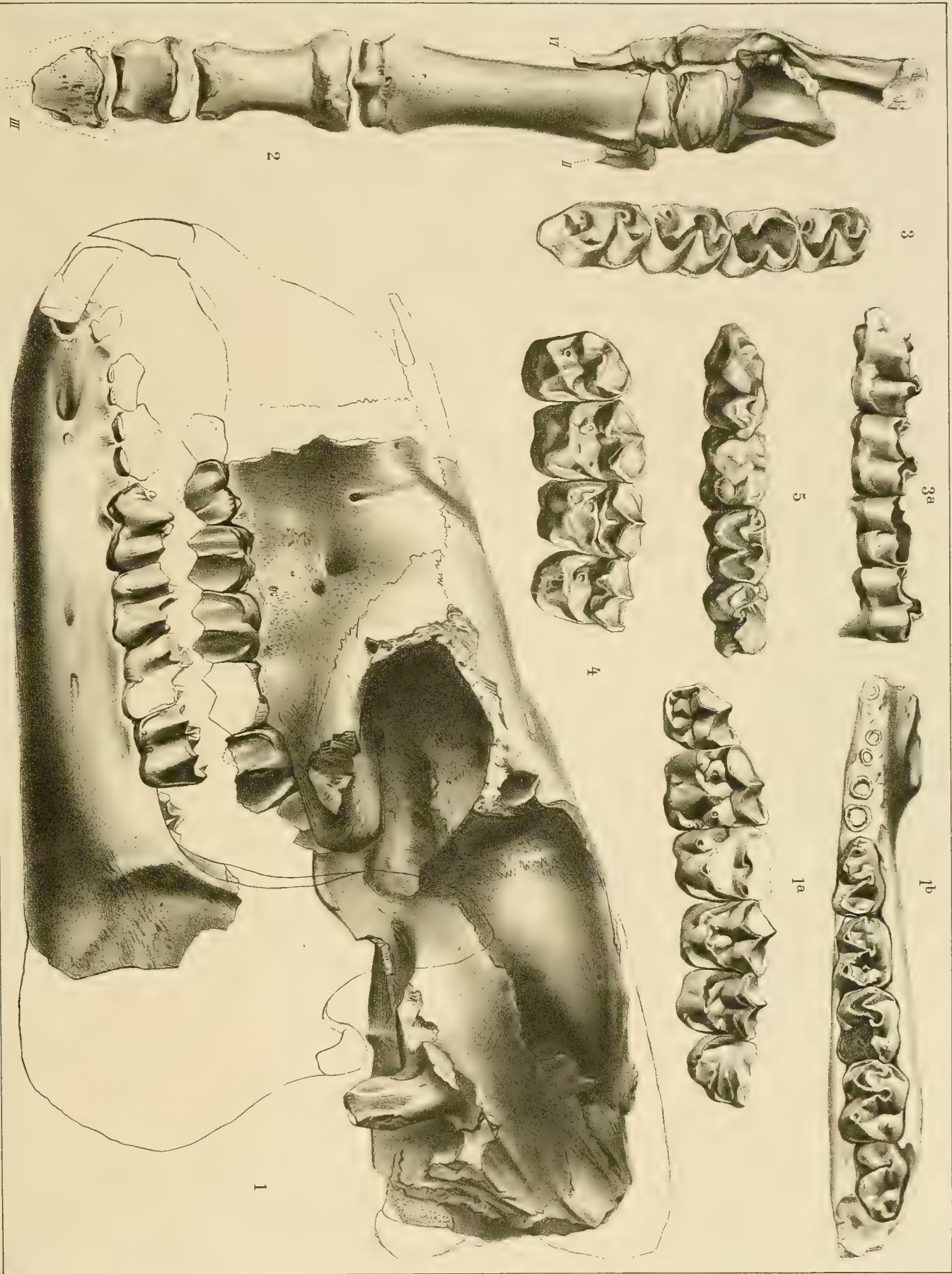
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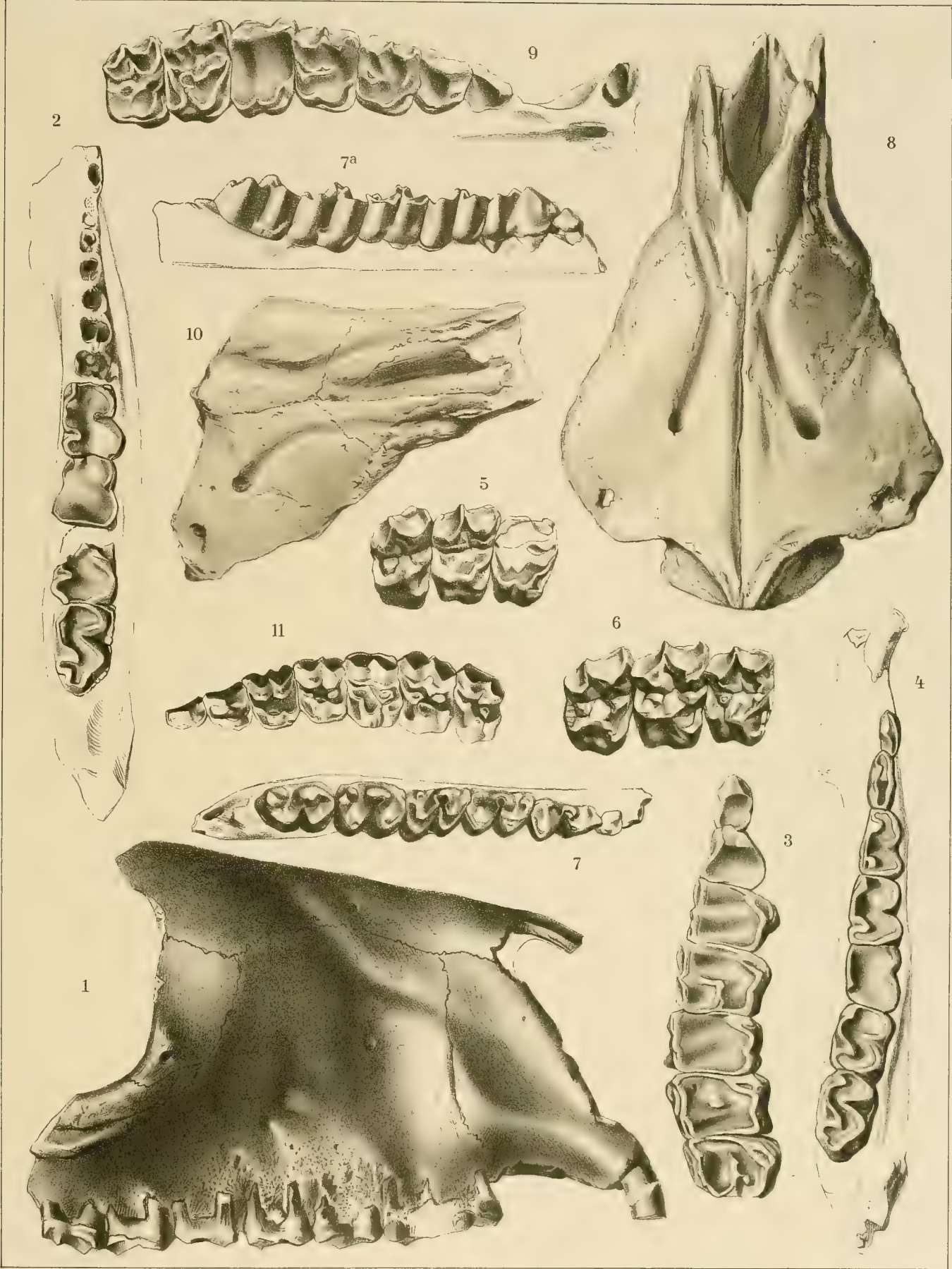
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All figures natural size.



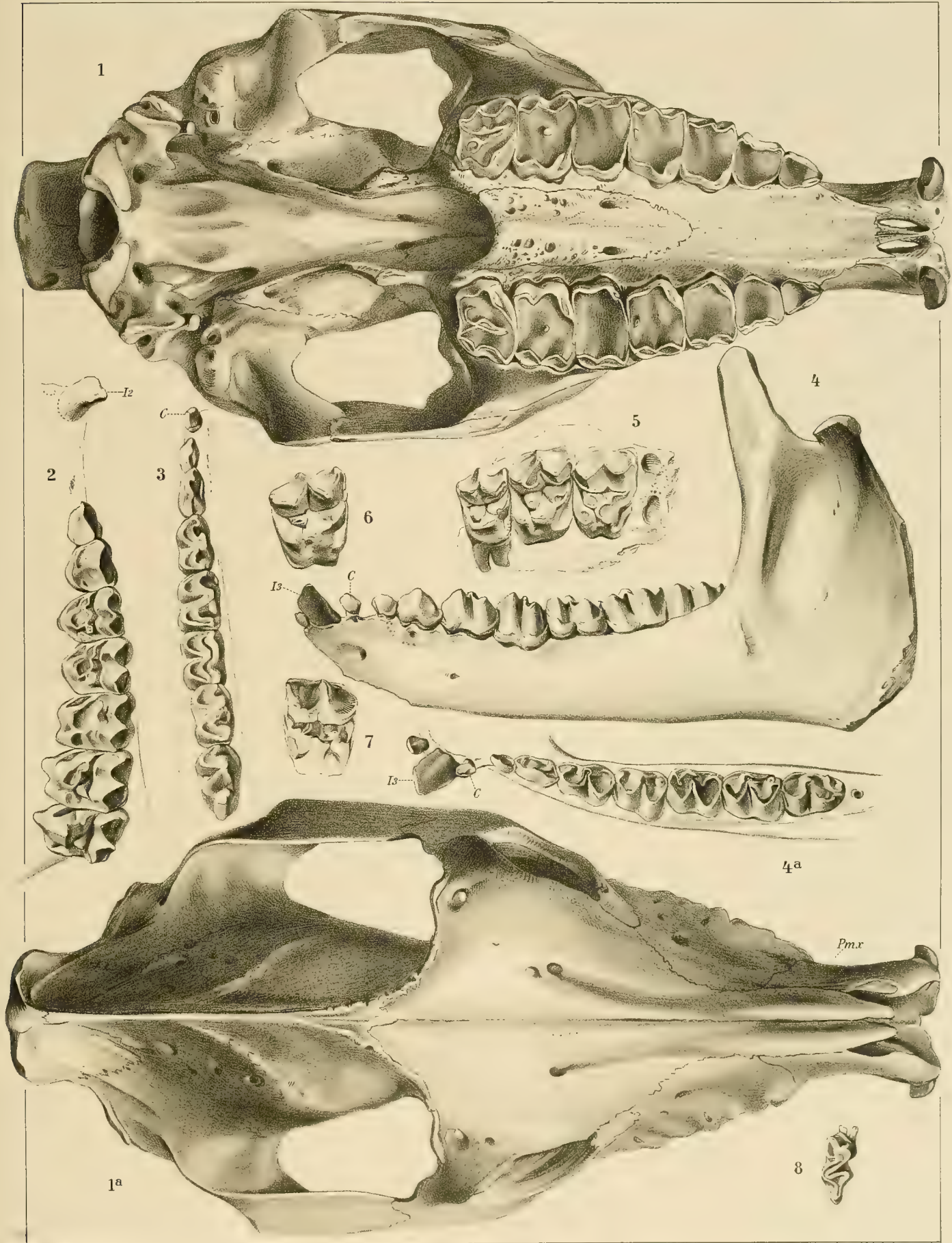
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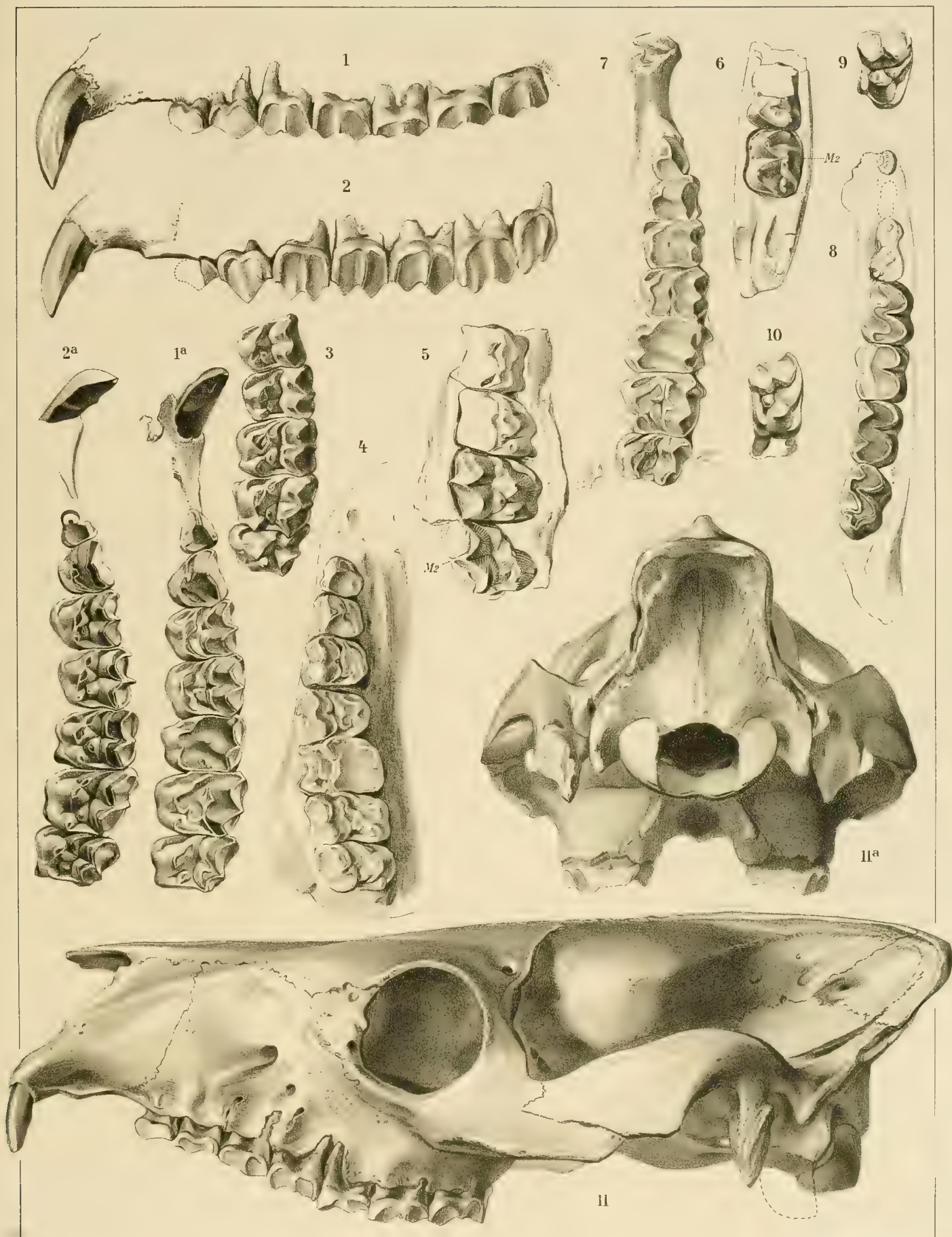
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PROTHEROTHERIUM

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All figures natural size.



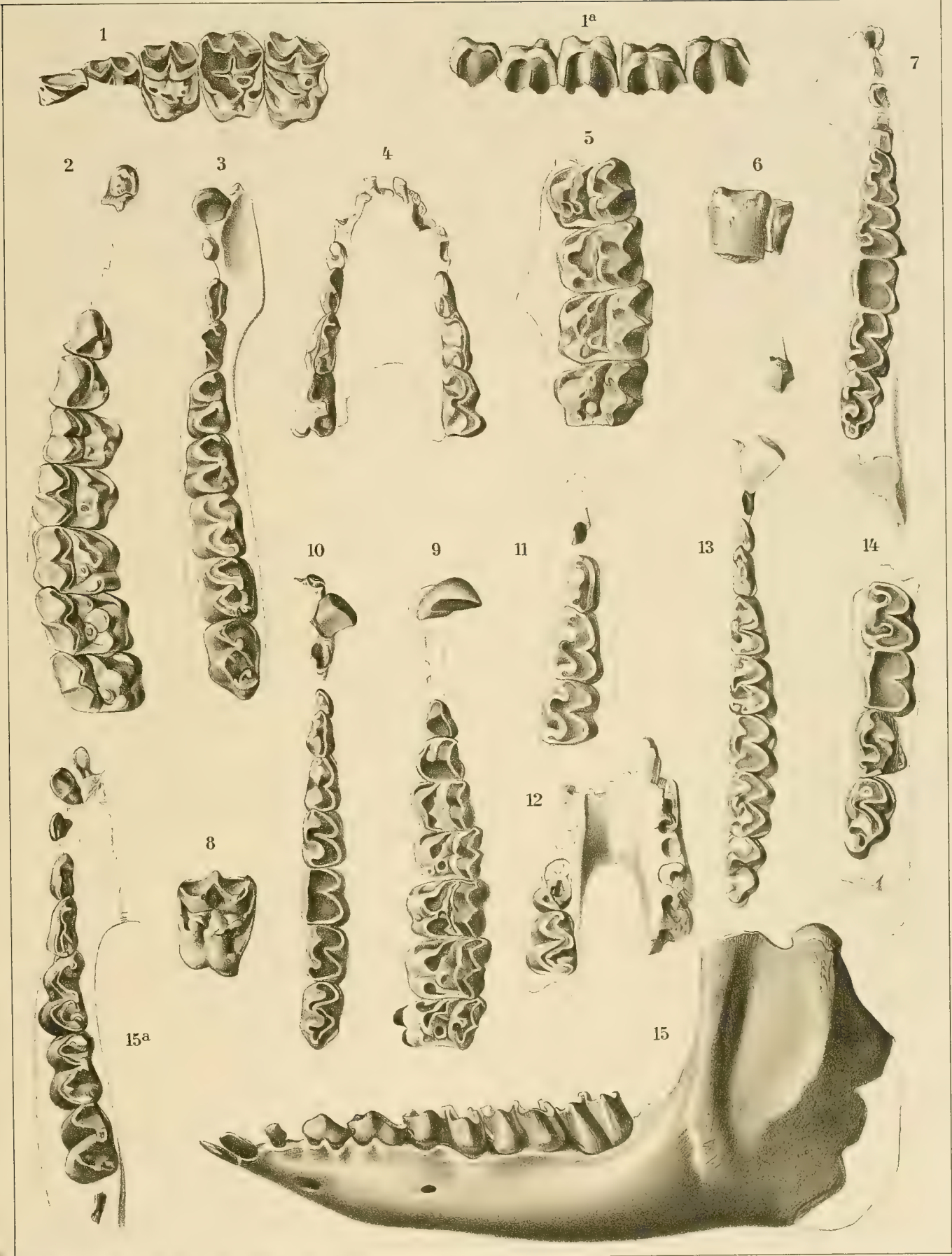
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All figures, except fig. 6, are natural size.



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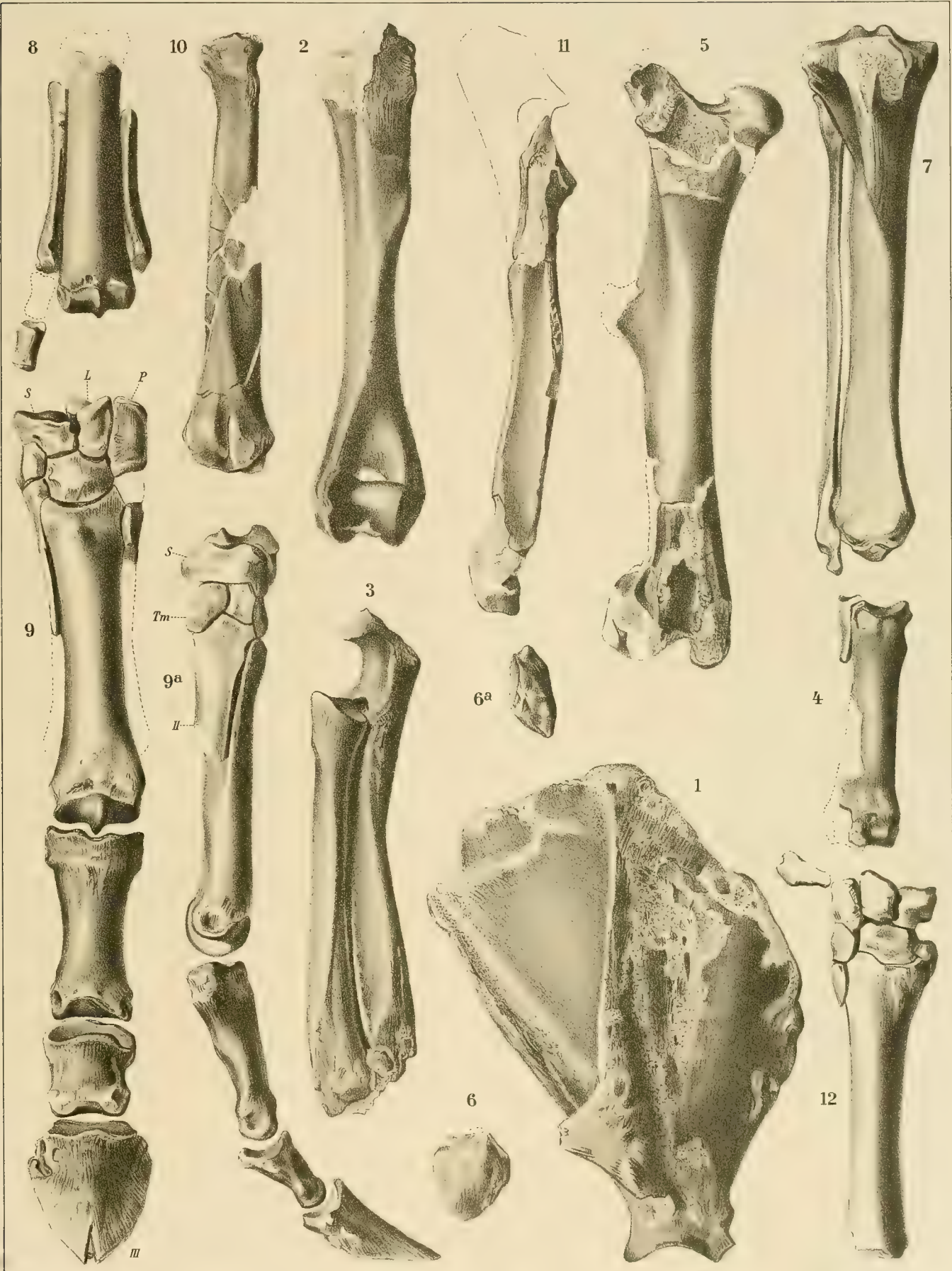
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PROTOTHERIUM

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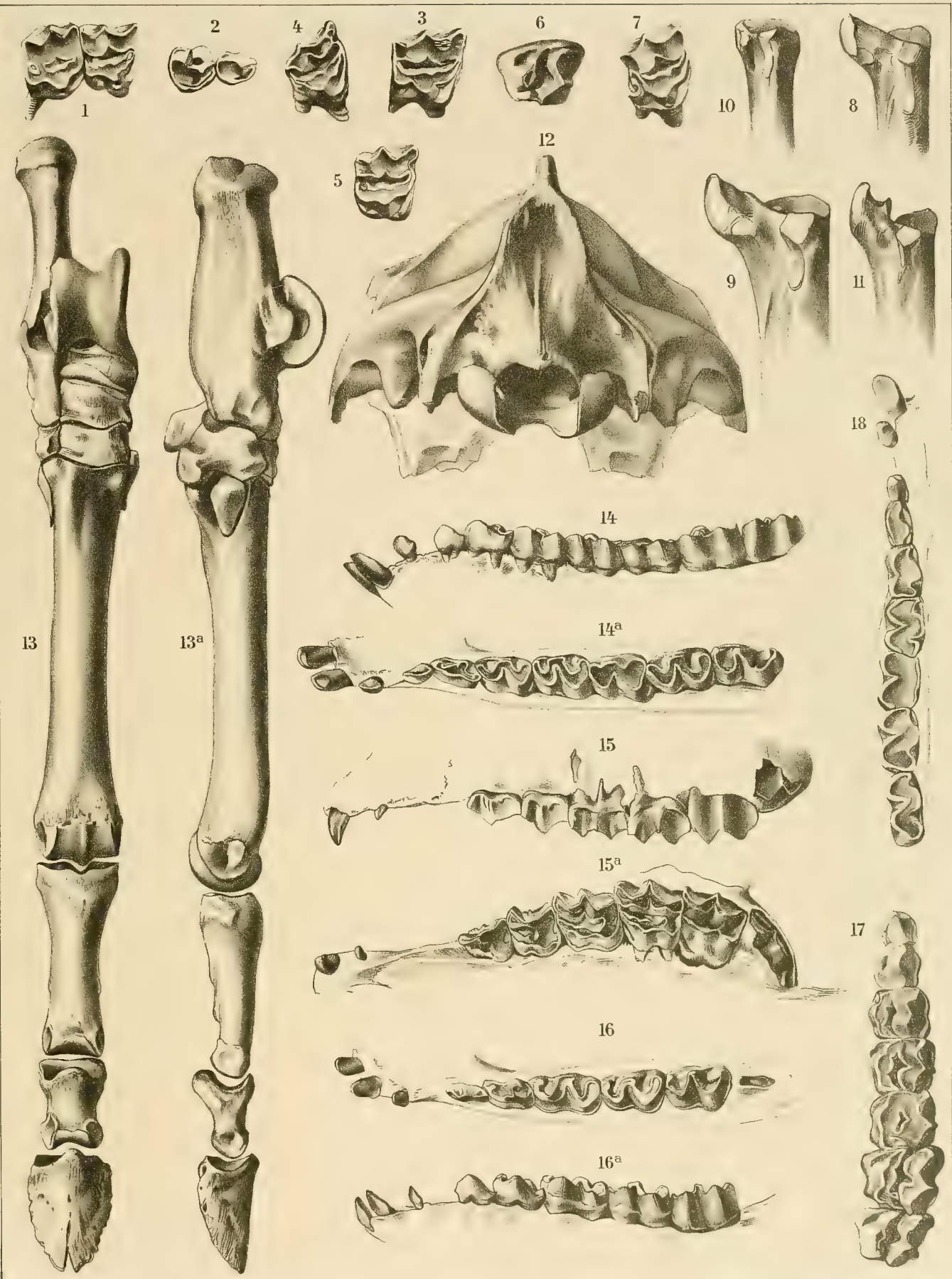
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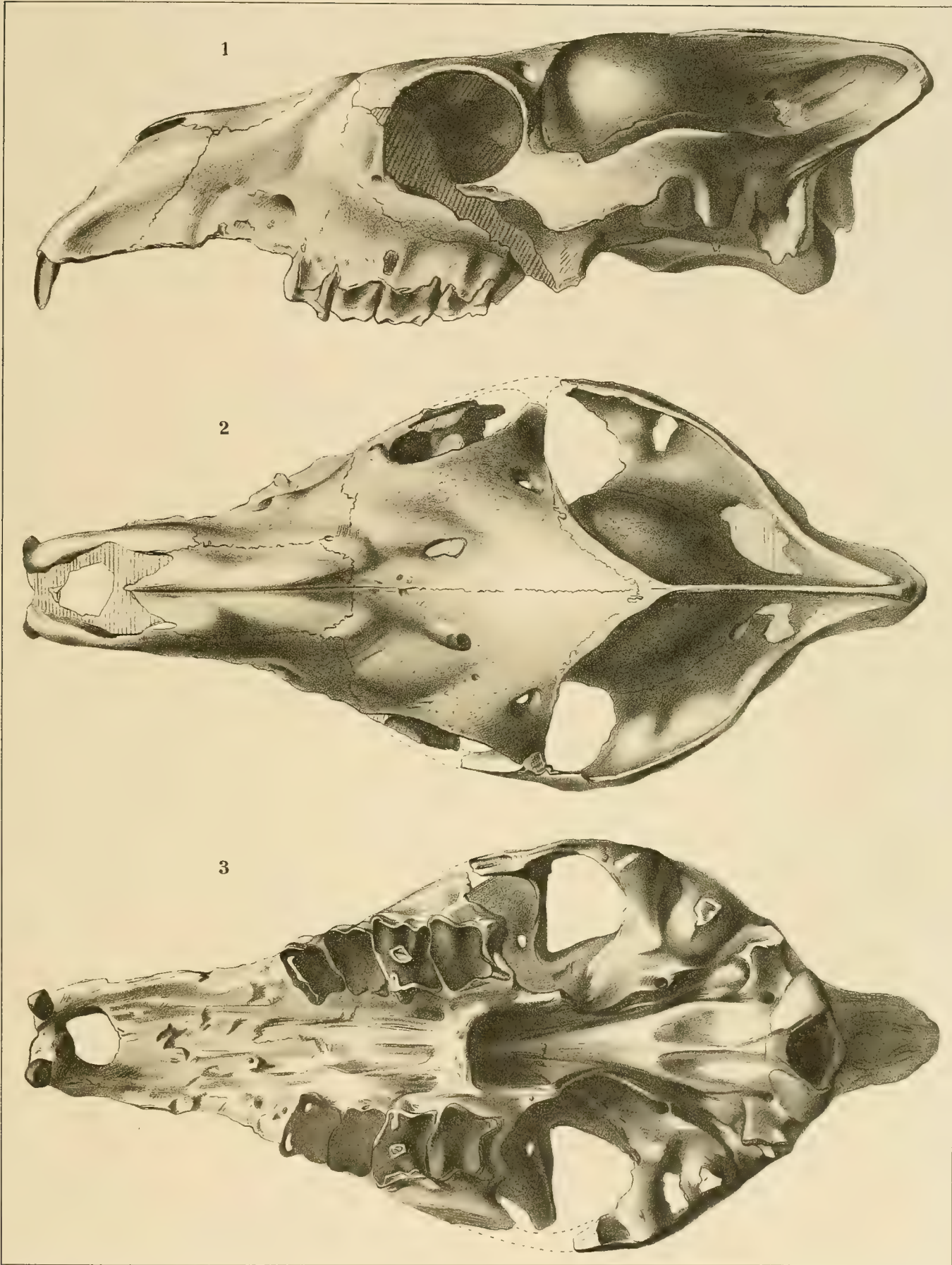
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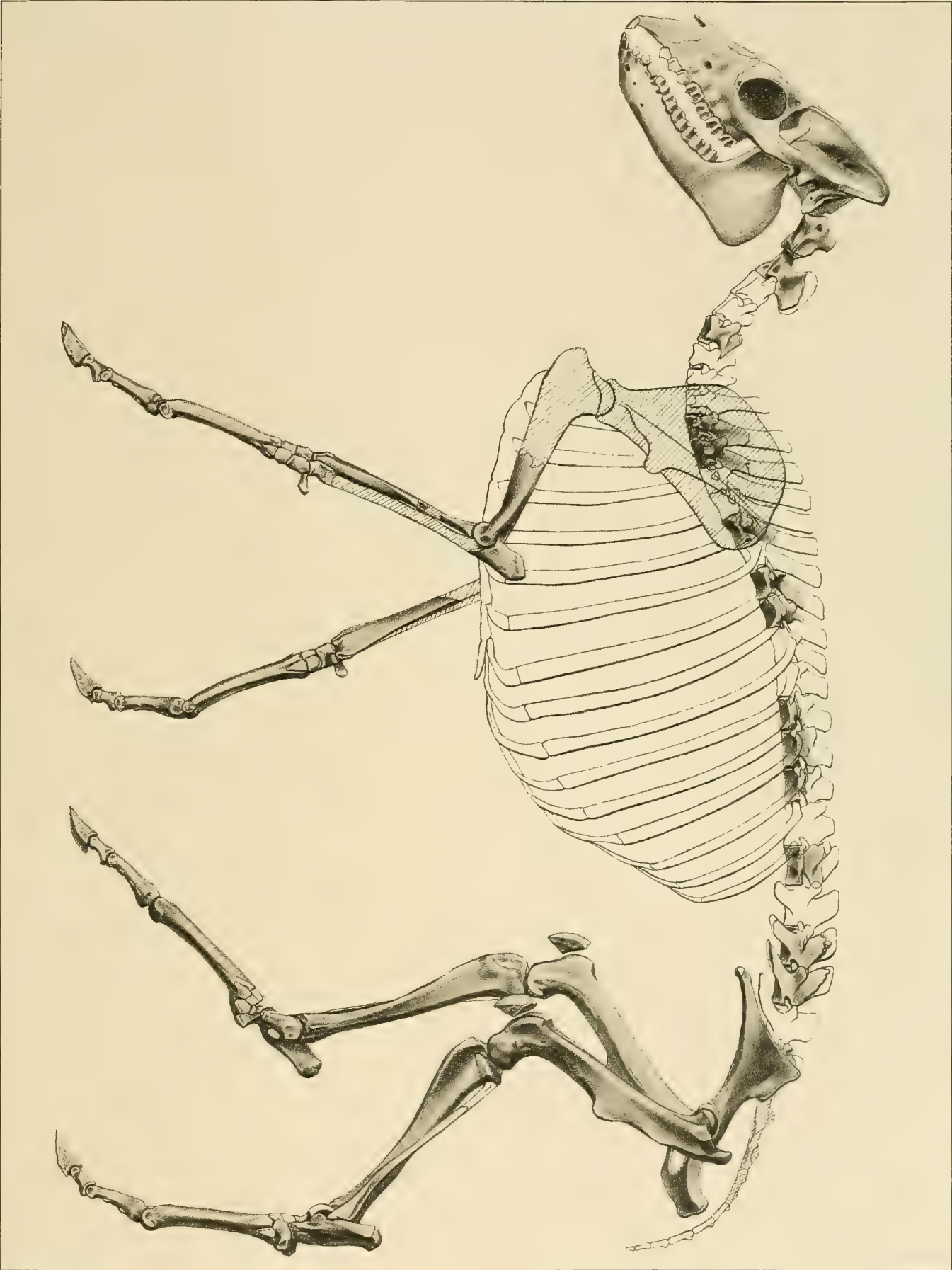
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THOATHERIUM

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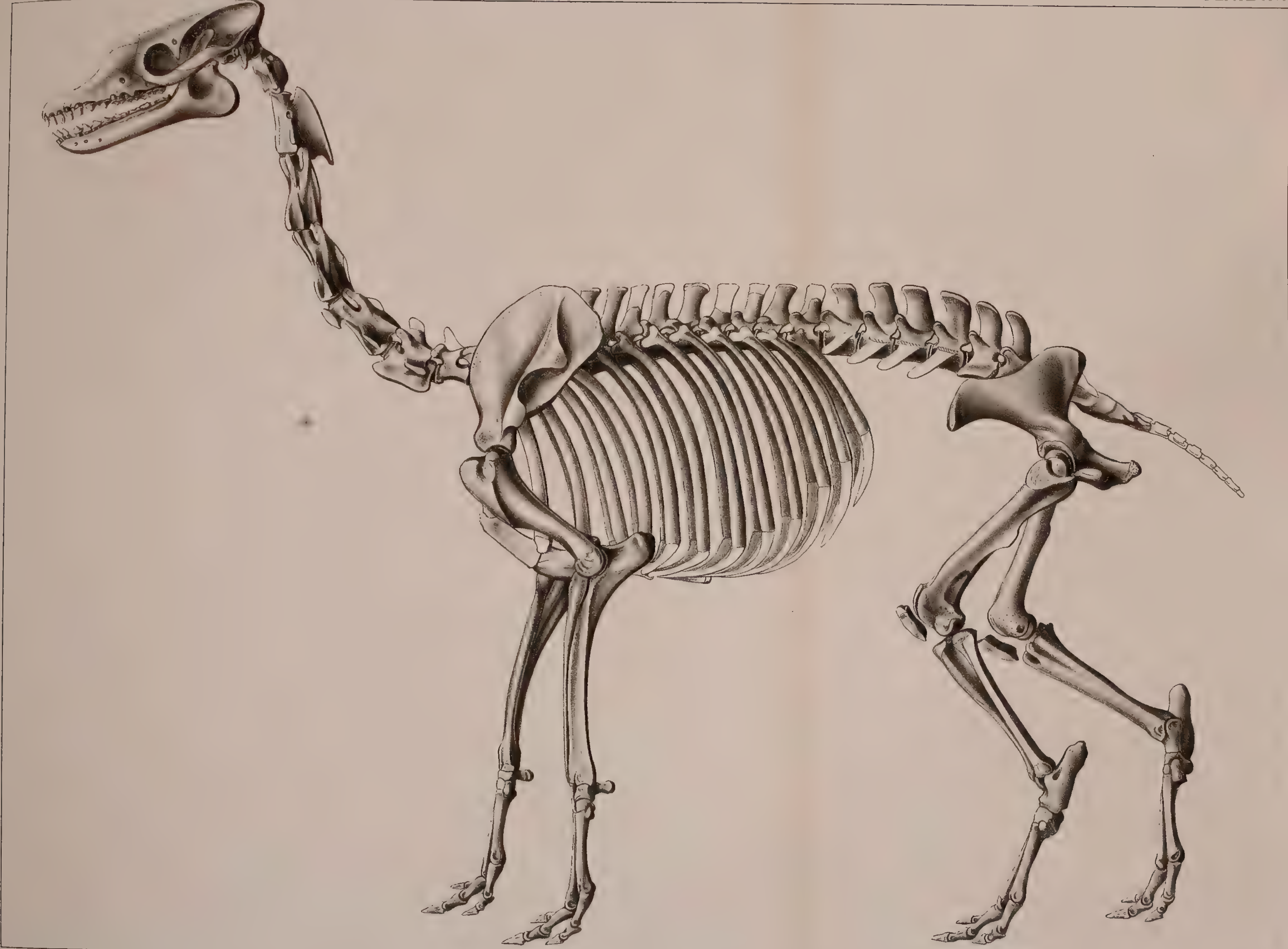
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PATAGONIAN EXPEDITION



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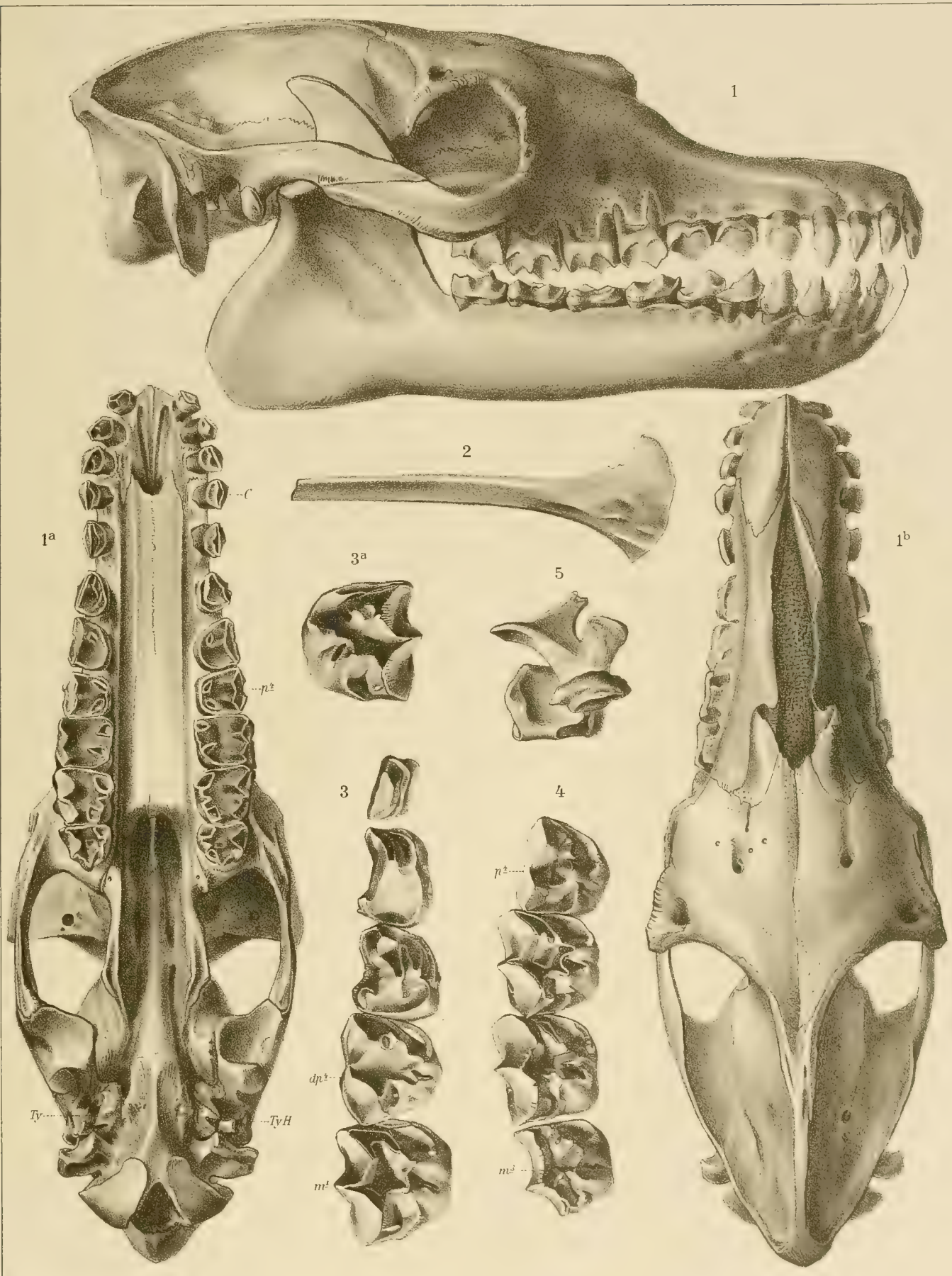
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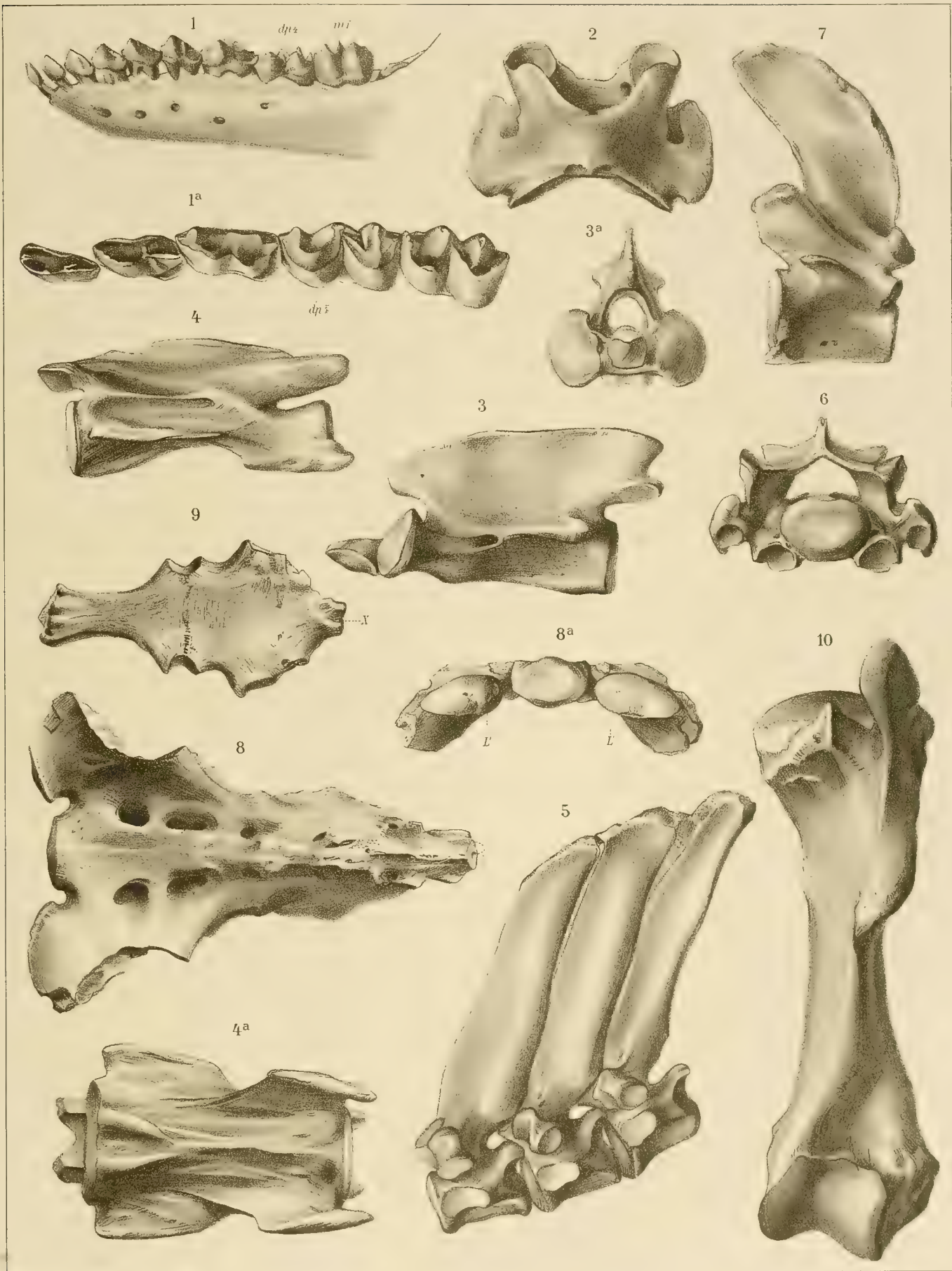


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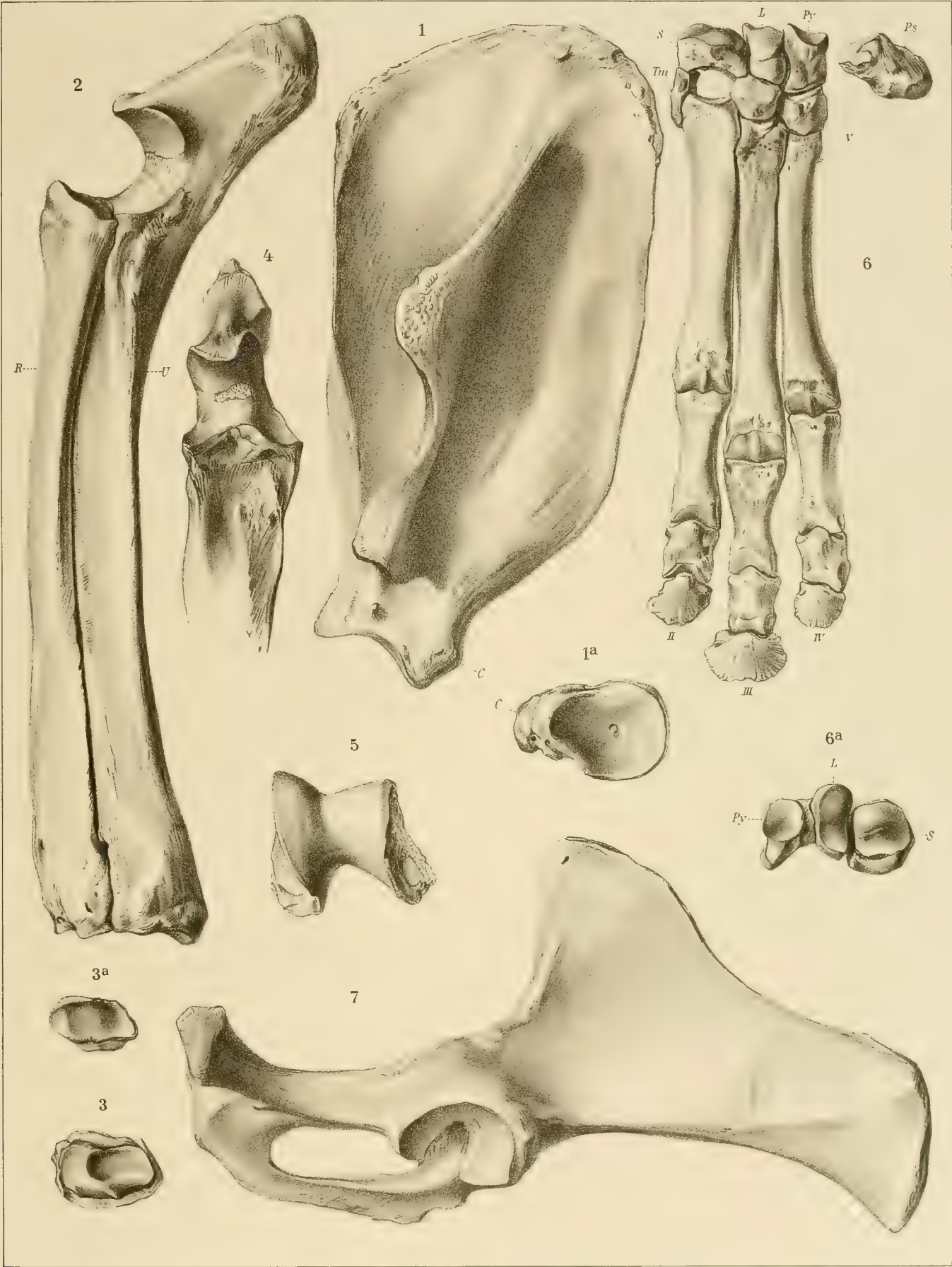
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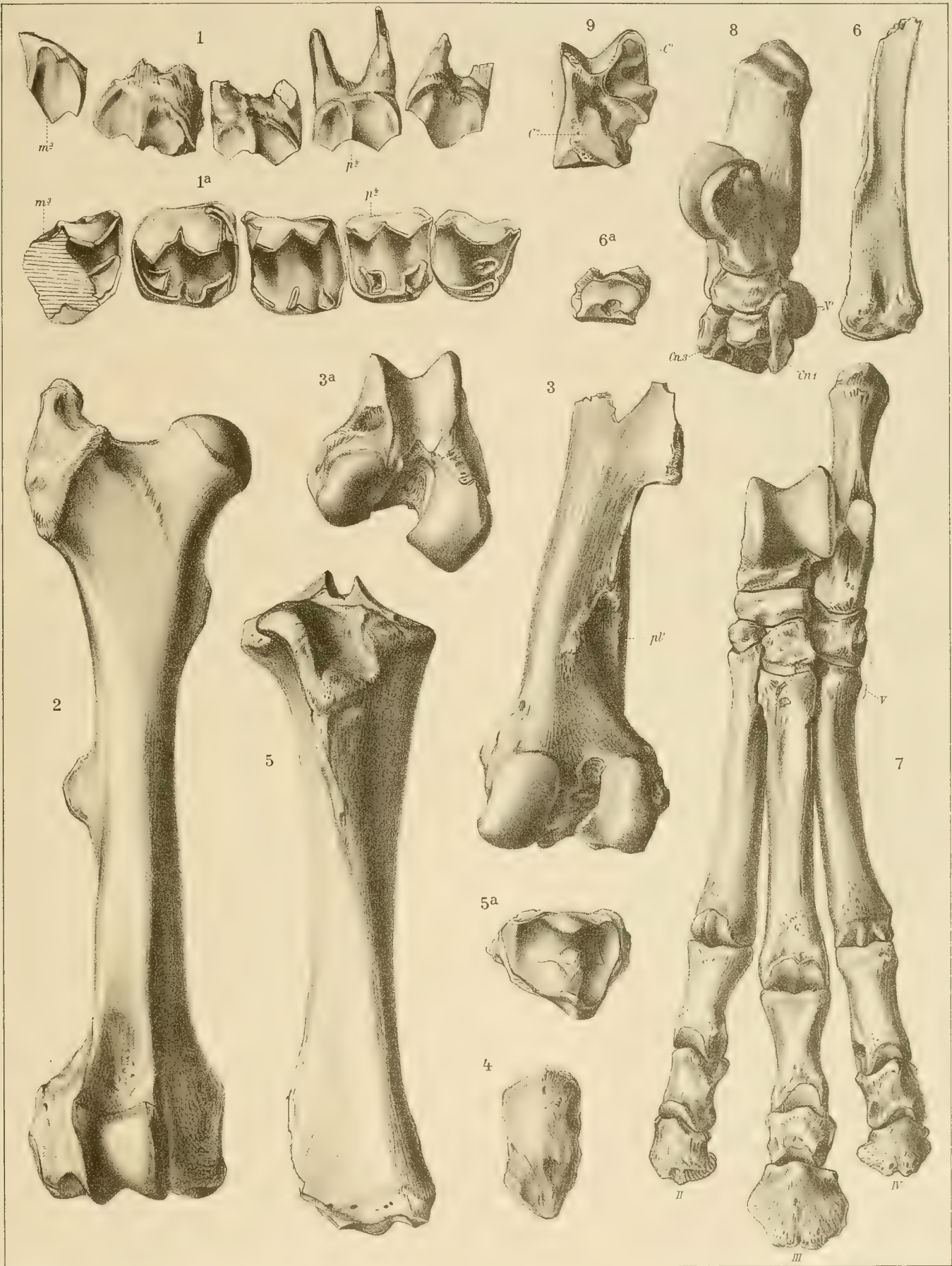


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